UNCLASSIFIED

AD 284 914

Reproduced
by the

ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA

UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

63-1-1

NOLTR 62-35

28491 4

CATALOGED BY ASTIA
AS AD No.

SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW

RELEASED TO ASTIA
BY THE NAVAL ORDNANCE LABORATORY
☑ Without restrictions
☐ For Release to Military and Government Agencies Only.
☐ Approval by BuWeps required for release to contractors.
☐ Approval by BuWeps required for all subsequent release.

NOL

8 JUNE 1962

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 62-35

284 914

OCT 1962

NOLTR 62-35

Aerodynamics Research Report No. 174

SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW

by

Lionel Pasiuk

ABSTRACT: Measurements of the static pressure and aerodynamic heat transfer on the surface of a sphere-cone model at Mach numbers of 3.23 and 4.33, and angles of yaw of 6° and 18° have been made. The results of several theoretical methods for calculating both the laminar and turbulent heat transfer to the body along the most windward and leeward streamlines are compared with the experimental measurements. The experimental laminar heat-transfer distributions are nearly alike for the two Mach numbers, when they are expressed in the form of the Nusselt number divided by the square root of the Reynolds number. The experimental heat-transfer data indicate that an increasing angle of yaw can induce transition from laminar to turbulent boundary layer.

PUBLISHED JULY 1962

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 62-35

8 June 1962

Supersonic Aerodynamic Heat Transfer and Pressure Distribution on a Sphere-Cone Model at High Angles of Yaw

This report represents the experimental phase of a project undertaken at NOL to obtain a more complete understanding of the heat transfer to blunt re-entry type bodies at angles of yaw. Measurements of the surface pressures and heat transfer to a yawed sphere-cone model in supersonic air flow have been made, and the data are compared with several theories.

This work was sponsored by the Bureau of Naval Weapons under Task No. RMGA-42-034/212-1/F009-10-001.

The author is indebted to Mr. S. M. Hastings for his stimulating comments and recommendations. He also wishes to acknowledge the valuable assistance of Mr. R. Chatham in making heat-transfer calculations, Mr. J. A. Iandolo in the mechanical design of the sting and roll mechanism, Mr. R. C. Sullivan in instrumenting and installing the model, and Mr. J. M. Kendall and Mr. G. W. Payne in building the related equipment for measuring temperatures.

W. D. COLEMAN
Captain, USN
Commander

FLORIAN GEINEDER
By direction

CONTENTS

ILLUSTRATIONS

TABLES

SYMBOLS

C_p	local pressure coefficient
$C_{p_{max}}$	stagnation point pressure coefficient
c_p	specific heat at constant pressure
H	enthalpy
k	thermal conductivity
M	Mach number
n	coordinate normal to model surface
Nu	Nusselt number, $Qc_{p_o}r/k_{o_e}(H_{o_e}-H_w)$
p	local static pressure
p_o'	stagnation point pressure
Q	local heat-transfer rate
R	model base radius
Re	Reynolds number as given by $\dfrac{\rho_{o_e}\ H_{o_e}^{1/2}\ r}{\mu_{o_e}}$
Re_∞	free-stream Reynolds number per unit length as given by $\rho_\infty U_\infty/\mu_\infty$
S	distance along a meridian on the surface of the model measured from the point where the axis of symmetry intersects the surface of the spherical nose
T	local static temperature
t	time
U_∞	free-stream velocity
W	velocity in the roll direction
α	angle of yaw
η	an angle that describes the inclination of the model surface to the free-stream flow and is the angle between the free-stream velocity vector and the line normal to the surface

μ	viscosity
ρ	density
ψ	roll angle

Subscripts

ADJ	adjusted
MEAS	measured
o	stagnation conditions
o_e	local stagnation conditions at the outer edge of the boundary layer
w	the external surface of the model
∞	free stream

INTRODUCTION

High-speed missiles such as ballistic missile re-entry bodies, maneuverable interceptor missiles, and hypersonic glide vehicles are apt to fly at angles of yaw; therefore, it is necessary for the missile designer to be able to estimate the effect of the angle of yaw on the aerodynamic heat transfer to these missiles.

This report represents the experimental phase of a project undertaken at the Naval Ordnance Laboratory to achieve a better understanding of the problem of heat transfer to bodies at angles of yaw. Surface pressure and heat transfer data are presented for a sphere-cone model exposed to a supersonic air stream at angles of yaw. The heat-transfer data are obtained by measuring the steady-state temperatures on the boundaries of the model shell and solving the steady-state three-dimensional heat conduction equation utilizing an iteration process. Some comparisons are made between the experimental and theoretical heat-transfer data on the most windward and leeward streamlines of the model. Additional calculations along the streamlines will be made and the results will be presented in a future report.

The sphere-cone model used for this experimental investigation has been used previously to obtain heat-transfer data at $M = 3.23$, $\alpha = 0^{\circ}$, and $M = 4.83$, $\alpha = 0^{\circ}$ and 6°, and the data are reported in reference (1).

EXPERIMENTAL TESTING EQUIPMENT

Test Facility

Both the heat transfer and pressure measurements were made in the NOL Supersonic Wind Tunnel No. 2 which is described in reference (2). The supply conditions of the test are listed in the following table.

M	T_o	p_o	Re_{∞}
3.23	318°K	980 mm Hg	$2.43 \times 10^6 ft^{-1}$
4.83	320°K	2090 mm Hg	$2.50 \times 10^6 ft^{-1}$

Description of Model

The sphere-cone model is made from type 347 stainless steel. It is instrumented with 60 stainless steel-constantan thermojunctions and each thermojunction is formed by welding

constantan wire of 0.005-inch diameter to the model wall. As shown in figure 1, the thermojunctions and pressure taps lie in the same meridian plane. The 11 pressure taps are located on one side of the axis of symmetry and the thermojunctions are located on the other side. The thermojunctions are located on both the inside and outside surfaces of the model wall. Table 1 gives the S/R values of both the thermojunctions and pressure taps. A more complete description of the construction of the sphere-cone model can be found in reference (1).

Instrumentation

A schematic diagram of the test setup is shown in figure 2. Continuous traces of p/p_o versus roll angle are recorded for one surface pressure tap at a time on a Kendall pressure ratio recorder which is described in reference (3). The surface pressure and supply pressure could also be read independently on a Wallace and Tiernan mercury manometer and Wallace and Tiernan pressure gage, respectively, in order to check the pressure ratio recorder.

The roll angle is recorded on the pressure ratio recorder and also displayed on the console of a self-balancing potentiometer which is a single channel of ADAPS (ref. (4)). The ADAPS is essentially a self-balancing potentiometer that balances the voltage drop across a variable resistor. The variable resistor is mounted on the model support and is geared to the rolling motion of the model. The rolling motion of the model is transmitted to the pressure ratio recorder by mounting a servo-transmitter on the ADAPS. The servo-transmitter is geared to the drive shaft of ADAPS and it sends an electrical signal to a servo-receiver on the pressure ratio recorder and to the visual readout.

Cooling of the sphere-cone model is achieved by circulating DC 200 silicone oil through the inside of the model. The silicone oil is passed through a coiled tube of a heat exchanger, the coil being immersed in a solid carbon dioxide-alcohol bath. A Taylor temperature controller keeps the silicone oil at a constant temperature of $223^{o}K \pm 0.5^{o}K$. The temperature of the silicone oil is $230^{o}K \pm .5^{o}K$ as it enters the model, and is $235^{o}K \pm .5^{o}K$ as it leaves the model. These temperatures are continually monitored on two General Electric millivolt recorders.

The output of each of the thermocouples is measured with a single channel of PADRE (ref. (5)), which is a self-balancing potentiometer. The potentiometer is set to a full-scale reading of 1 MV, thereby giving a voltage sensitivity of $\pm$ 0.6 μV and a temperature sensitivity of $\pm 0.02^{o}K$. The

thermocouples are automatically switched one at a time to the potentiometer.

As shown in figure 3, the thermocouples on the outside surface of the model use an ice-water bath as a reference. The thermocouples on the inside surface and in the model wall, at a given S/R station, use the temperature on the outside surface at that S/R station as a reference. Because temperature differences exist that give a voltage greater than 1 MV, it is necessary to provide a millivolt source to counteract any signals in excess of 1 MV.

EXPERIMENTAL PROCEDURE

Pressure Data

Each of the 11 surface pressure taps is connected one at a time to the pressure ratio recorder. A continuous trace of p/p_o' versus ψ is produced when the model is rolled from the most windward to the most leeward position. The rolling motion is stopped every 15^o, and the surface pressure and supply pressure are read on a mercury manometer and pressure gage, respectively.

Temperature Data

The temperature distribution through the model wall is obtained in the following manner. With the supply conditions of the wind tunnel and the model coolant constant with respect to time, the model is placed at the initial roll position of $\psi = 0^o$. After the temperatures throughout the model wall reach their steady-state values, they are recorded. The model is then rotated to the next roll position and this procedure is repeated. Temperature measurements are made in the region $0^o \leq \psi \leq 180^o$, at increments of $\Delta\psi = 15^o$.

RESULTS AND DISCUSSION

Pressure Results

Pressure distributions on the sphere-cone model are presented in table 2. They are given in the dimensionless form p/p_o' versus S/R for various values of the roll angle ψ in increments of 5^o.

Figures 4, 5, 6, and 7 are representative plots of p/p_o' versus S/R for $\psi = 0^o$, 90^o, and 180^o at $\alpha = 6^o$ and 18^o, at $M = 3.23$ and 4.83. The Newtonian flow $(C_p/C_{p_{max}} = \cos^2\eta)$ predicts a pressure distribution on the spherical nose that

is slightly higher than the experimental data. On the conical afterbody the pressures calculated from Newtonian flow and the Kopal cone tables (refs. (6), (7), and (8)) are slightly lower than the experimental data. Both the Newtonian and Kopal values predict a constant pressure as a function of S/R along the most windward and leeward streamlines of the cone section, whereas the experimental pressure distributions show a slight overexpansion in the region of the sphere-cone junction and then a slight compression to a constant pressure with increasing S/R.

For various values of S/R a cross plot of the pressure distributions, that is, p/p_0' versus ψ, is shown in figure 8. The data for $\alpha = 18^o$ at Mach numbers of 3.23 and 4.83 are presented. The experimental data are shown as they are recorded, that is, as continuous curves of pressure versus roll angle. The pressure level is slightly greater at M = 3.23 than at M = 4.83.

Temperature Results

All of the measured temperature distributions are presented in table 3. They are given in degrees Kelvin versus S/R for various values of roll angle ψ in increments of 15^o.

Figures 9, 10, and 11 are plots of the measured wall temperatures of the model, versus S/R, for $\psi = 0^o, 90^o$, and 180^o, and with M = 4.83 and $\alpha = 18^o$. Notice that the temperature on the surface of the spherical nose of the model at S/R = 0 varies almost 3^oC as ψ goes from 0^o to 180^o. Under ideal conditions, that is, if tunnel supply conditions and the temperature of the coolant fluid inside the model remain constant, the temperature at the point S/R = 0 should remain constant because this point is on the axis of rotation of the spherical nose of the model and remains in the same position relative to the air flow. As can be seen in figure 12 the varying temperature at S/R = 0 gives a discontinuity in the temperature distribution at S/R = 0. It is likely that the discontinuity is caused by an asymmetry in the geometry of the model due to the presence of the pressure taps. In order to eliminate this discontinuity, the temperature at S/R = 0, for all roll positions of $\psi > 0^o$, is adjusted so that it is equal to the temperature at $\psi = 0^o$. Then the assumption is made that the entire temperature distribution at a constant roll position shifts by the same amount as the change in temperature at S/R = 0. The equation for the temperature adjustment is:

$$T_{ADJ}(\psi, S/R) = T_{MEAS}(0,0) - T_{MEAS}(\psi,0) + T_{MEAS}(\psi, S/R) \quad (1)$$

This alters the temperature distribution as a function of the roll angle, but does not change the temperature difference across the wall. The adjustments in temperature do not change the ratio T_w/T_o more than 5 percent. Figure 12 illustrates how the discontinuity in the temperature distribution is eliminated by the temperature adjustment. Figure 13 is a plot of temperature versus roll angle for $M = 4.83$, $\alpha = 18^o$, and $S/R = 0$ and 0.52. This figure illustrates how the temperature distribution in the roll direction is affected by the temperature adjustment.

Heat-Transfer Data Reduction

The calculation of the aerodynamic heat transfer is performed by utilizing the steady-state method. A detailed description of the steady-state method can be found in reference (9). In general, this method requires the solution of the three-dimensional, steady-state heat conduction equation. Specifically for this problem, the shell of the model is separated into two regions. The first region is the spherical section and the second region is the conical section. The three-dimensional steady-state heat conduction equation is written in spherical and rectangular coordinate systems for the first and second regions, respectively. Then the heat conduction equation is replaced by a set of finite difference equations and the steady-state adjusted temperatures on the boundaries of the model shell are used to compute the temperature within the model shell utilizing an iteration process. The calculated temperature field is then used to find the temperature gradient normal to the model surface, and the local aerodynamic heat transfer to the model surface is:

$$Q = k \frac{\partial T}{\partial n} \quad . \tag{2}$$

The variation of the thermal conductivity of the stainless-steel model as a function of temperature has been measured by the National Bureau of Standards and the results are presented in reference (10). In the temperature region,

$$223^oK \leq T \leq 273^oK$$

the thermal conductivity can be approximated by

$$k = (6.354 \times 10^{-6})\ T + (2.31 \times 10^{-3}) \tag{3}$$

where the units are:

T	^oK
k	BTU/sec-ft-^oK .

Heat-Transfer Results

Heat-transfer results are given in the form of the Nusselt number divided by the square root of the Reynolds number as suggested in reference (11) and the equation is:

$$\frac{Nu}{Re^{1/2}} = \frac{Qc_{p_o} \; r/k_{o_e} \; (H_{o_e}-H_w)}{(\rho_{o_e} \; H_{o_e} \; r/\mu_{o_e})^{1/2}} \quad . \tag{4}$$

If c_p = constant (c_p varies about 0.3 percent in the temperature range encountered in this experiment) and if the local stagnation density, pressure, and enthalpy are constant about the body, then equation (4) can be written in the form:

$$Nu/Re^{1/2} = (\text{constant}) \; \frac{Q}{T_o - T_w} \tag{5}$$

where

$$(\text{constant}) = \frac{r/k_{o_e}}{(\rho_{o_e} \; H_{o_e} \; r/\mu_{o_e})^{1/2}} \quad . \tag{6}$$

Figure 14 is a plot of the heat-transfer data versus S/R for $M = 4.83$, $\alpha = 18^\circ$, and $\psi = 0^\circ$, 90°, and 180°.

Theoretical calculations of the laminar heat transfer have been made for both the windward ($\psi = 0^\circ$) and leeward ($\psi = 180^\circ$) streamlines and the results are shown in figure 14. On the windward streamline ($\psi = 0^\circ$), the analysis of Vaglio-Laurin (ref. (12)) as formulated by Zakkay (ref. (11)) is used to compute the heat transfer downstream from the aerodynamic stagnation point. Using this method two calculations are made. The first calculation is made under the assumption that the heat transfer on the windward streamline is equivalent to that on an axially symmetric sphere-cone body which has a new cone half angle of the actual body plus the angle of yaw. In the second calculation, the effect of the crosswise velocity gradient $dw/d\psi$ on the spreading of the streamlines of the inviscid flow is approximately accounted for and the value of $dw/d\psi$ is determined by using equations (1) and (A-22) of reference (11) and is assumed to be constant. The three constants in equation (1) of reference (11) are determined from the pressures that were measured at a constant S/R = 2.481, and $\psi = 0^\circ$, 90°, and 180°. Both calculations give the same heat-transfer values on the spherical nose of the body and these values are from 0 percent to 13 percent higher than experimental data. On the conical section of the body the former calculation compares favorably with the experimental data, as may be seen from figure 14, while the latter calculation predicts heat-transfer values that are approximately 30 percent higher than the measured data.

Another theoretical heat-transfer curve using the method of Reshotko (ref. (13)) is also computed for the most windward streamline of the cone. Reshotko's analysis is for a sharp cone at an angle of yaw and as might be expected, the theoretical results seem to approach the measured heat-transfer values toward the base of the cone.

Since the measured static pressure distribution is relatively constant for ψ between 135^o and 180^o on the conical section of the model, a calculation of the laminar heat transfer was made using flat-plate theory, and the results were transformed to the cone geometry by multiplying the flat-plate results by $\sqrt{3}$. This computation was made using the results of figure 6 of reference (14). The results agree favorably with the experimental data.

The heat transfer versus S/R for M = 3.23, α = 18^o, and ψ = 0^o, 90^o, and 180^o is shown in figure 15. Theoretical calculations of the heat transfer using the same methods described in the previous paragraph are also shown in figure 15. When the heat-transfer rates are presented in the form of $Nu/Re^{1/2}$, the experimental and theoretical laminar heat-transfer distributions do not change very much between M = 3.23 and M = 4.83. In figure 15, there is a sharp increase in the heat-transfer rates on the ψ = 90^o and 180^o curves, indicating that a transition from laminar to turbulent flow has taken place. Theoretical values of the turbulent heat transfer to the leeward streamline have been obtained by transforming the flat-plate theoretical results of reference (14) so that they apply for a sharp cone. The theoretical results compare very well with the experimental data.

It is interesting to note that the experimental data in figure 15 indicate that there is no transition from laminar to turbulent boundary layer on the most windward streamline (ψ = 0^o).

In order to illustrate where transition begins, figures 16 and 17 are presented. Figure 16 is a plot of the experimental heat-transfer parameter $Nu/Re^{1/2}$ versus ψ with S/R as a parameter. Values for S/R equal to 0.301, 1.392, and 2.636 are shown. The first two curves indicate that the heat-transfer rates decrease as ψ increases, whereas, the third curve shows that there is a sharp rise in the heat-transfer rates at ψ = 75^o. In figure 17, the experimental $Nu/Re^{1/2}$ is plotted against S/R and the ψ = 60^o data are completely laminar, however, the ψ = 75^o data show a sharp increase in the heat-transfer rates. The location of the laminar, transitional, and turbulent boundary layers on the conical section of the sphere-cone model are shown in figure 18. These regions are determined from the experimental

heat-transfer data. The point where the heat-transfer rates begin to rise is taken as the end of the laminar region and the point where the heat-transfer values reach a maximum is taken as the end of the transition region.

The region where transition begins is one where a true three-dimensional boundary layer with crossflow (that is, flow in the boundary layer normal to the external inviscid streamlines) does exist. Experiments having to do with flow on a rotating disk (ref. (15)) verify that a three-dimensional laminar boundary layer is extremely unstable. The Reynolds number based on local flow conditions and distance from the aerodynamic stagnation point to the base of the cone on the most windward streamline is 1.4×10^6, and there is no indication of transition. The Reynolds number at the beginning of transition at the point $S/R = 1.6$ and $\psi = 90^o$ is only 0.7×10^6.

CONCLUSIONS

Newtonian flow theory predicts pressures on the surface of the spherical nose of the sphere-cone model that are slightly higher than the experimental data. The surface pressures given by the Kopal cone tables are slightly higher than those measured on the surface of the cone. Neither computational method is adequate for predicting the pressures in the region of the sphere-cone junction.

The theoretical laminar heat-transfer distributions along the windward streamline approach the experimental data toward the base of the cone. In the region of the sphere-cone junction the theoretical laminar heat-transfer rates are over 100 percent higher than the experimental measurements. The prediction of both the laminar and turbulent heat-transfer rates to the leeward streamline are in very good agreement with the experimental data.

The experimental laminar heat-transfer distributions are very nearly the same for both the Mach number 3.23 and 4.83 data, when they are expressed in the form of the Nusselt number divided by the square root of the Reynolds number.

The Mach number 3.23 experimental heat-transfer data indicate that increasing angles of yaw can cause transition from a laminar to a turbulent boundary layer in a region on the conical section of the model between the most windward and leeward streamlines. The experimental turbulent heat-transfer at a point on the cone that is midway between the most windward and leeward streamlines are approximately 50 percent higher than the experimental laminar heat transfer at the most

windward streamline. This transition is probably due to the extreme instability of the three-dimensional laminar boundary layer that exists in this region.

REFERENCES

(1) Hastings, S. M. and Chones, A. J., "Supersonic Aerodynamic Heating of a Yawed Sphere-Cone Wind-Tunnel Model," NAVORD Report 6812, 28 June 1960

(2) Meek, P. P., "Aeroballistic Research Facilities," NOLR 1233, May 1959

(3) Kendall, J. M., "Equipment for Continuously Recording the Ratio of Two Pressures," NAVORD Report 4201, September 1955

(4) Gilbert, B. D., "Automatic Data Processing Systems (ADAPS) for the Supersonic Tunnels," NAVORD Report 2813, March 1953

(5) Kendall, J. M., "Portable Automatic Data Recording Equipment (PADRE)," NAVORD Report 4207, 24 August 1959

(6) Staff of the Computing Section, Center of Analysis, MIT, directed by Kopal, Z., "Tables of Supersonic Flow Around Cones," Technical Report No. 1, 1947

(7) Staff of the Computing Section, Center of Analysis, MIT, directed by Kopal, Z., "Tables of Supersonic Flow Around Yawing Cones," Technical Report No. 3, 1947

(8) Staff of the Computing Section, Center of Analysis, MIT, directed by Kopal, Z., "Tables of Supersonic Flow Around Cones of Large Yaw," Technical Report No. 5, 1949

(9) Orlow, T. A., "Numerical Solution of LaPlace's Equation for Various Three Dimensional Regions with Axial Symmetry," NAVORD Report 6038, 22 January 1958

(10) Robinson, H. E. and Watson, T. W., "Thermal Conductivity at Low Temperatures of Types 316 and 347 Stainless Steels," NBS Report 5748, January 1958

(11) Zakkay, Victor, "Pressure and Laminar Heat Transfer Results in Three-Dimensional Hypersonic Flow," WADC TN-58-182, ASTIA Document No. 155679, September 1958

(12) Vaglio-Laurin, Roberto, "Laminar Heat Transfer on Blunt-Nosed Bodies in Three-Dimensional Hypersonic Flow," WADC-TN-58-147, ASTIA Document No. AD 155588, May 1958

(13) Reshotko, Eli, "Laminar Boundary Layer with Heat Transfer on a Cone at Angle of Attack in a Supersonic Stream," NACA TN-4152, December 1957

(14) Van Driest, E. R., "The Problem of Aerodynamic Heating," Aeronautical Engineering Review, Vol. 15, No. 10, pp. 26-41, October 1956

(15) Gregory, N., Stuart, J. T., and Walker, W. S., "On the Stability of Three-Dimensional Boundary Layer with Application to the Flow Due to a Rotating Disk," Paper No. 3 from the International Symposium on Boundary Layer Effects in Aerodynamics, held at the National Physical Laboratory, Teddington, England, 31 March and 1 April 1955, published by Philosophical Library, Inc., 1957

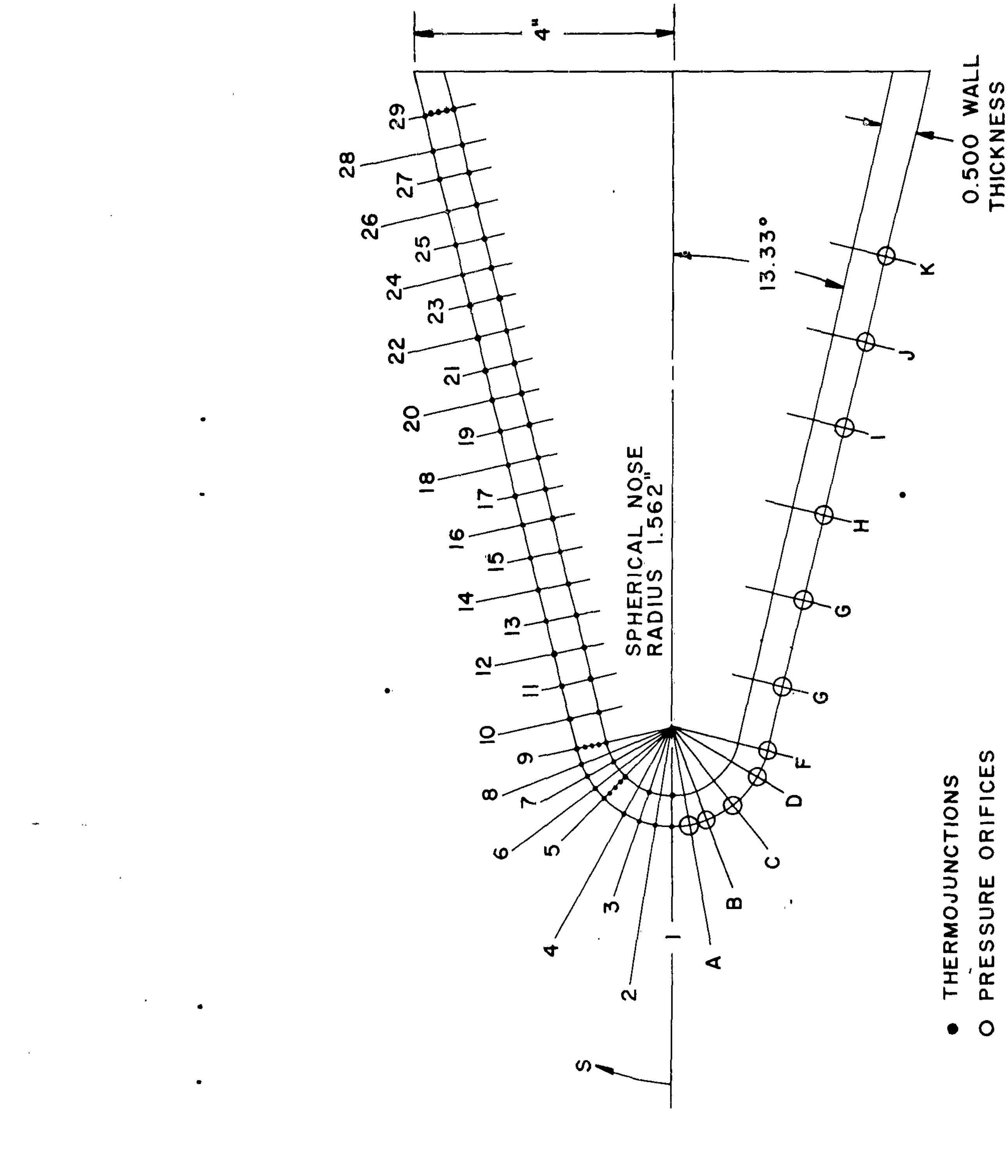

FIG. 1 SPHERE-CONE MODEL SHOWING THE LOCATION OF PRESSURE ORIFICES AND THERMOJUNCTIONS

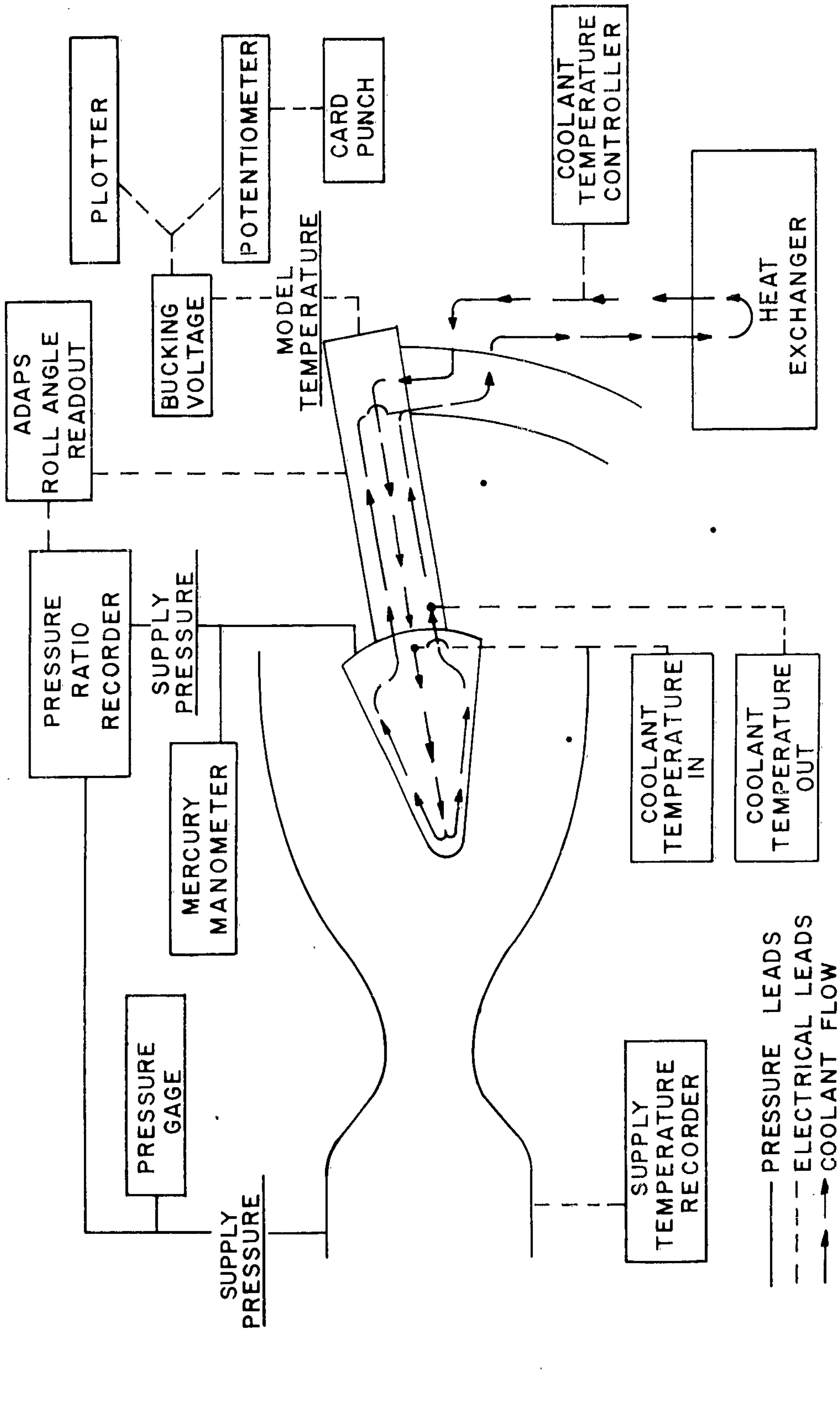

FIG 2 SCHEMATIC DIAGRAM OF THE TEST SETUP

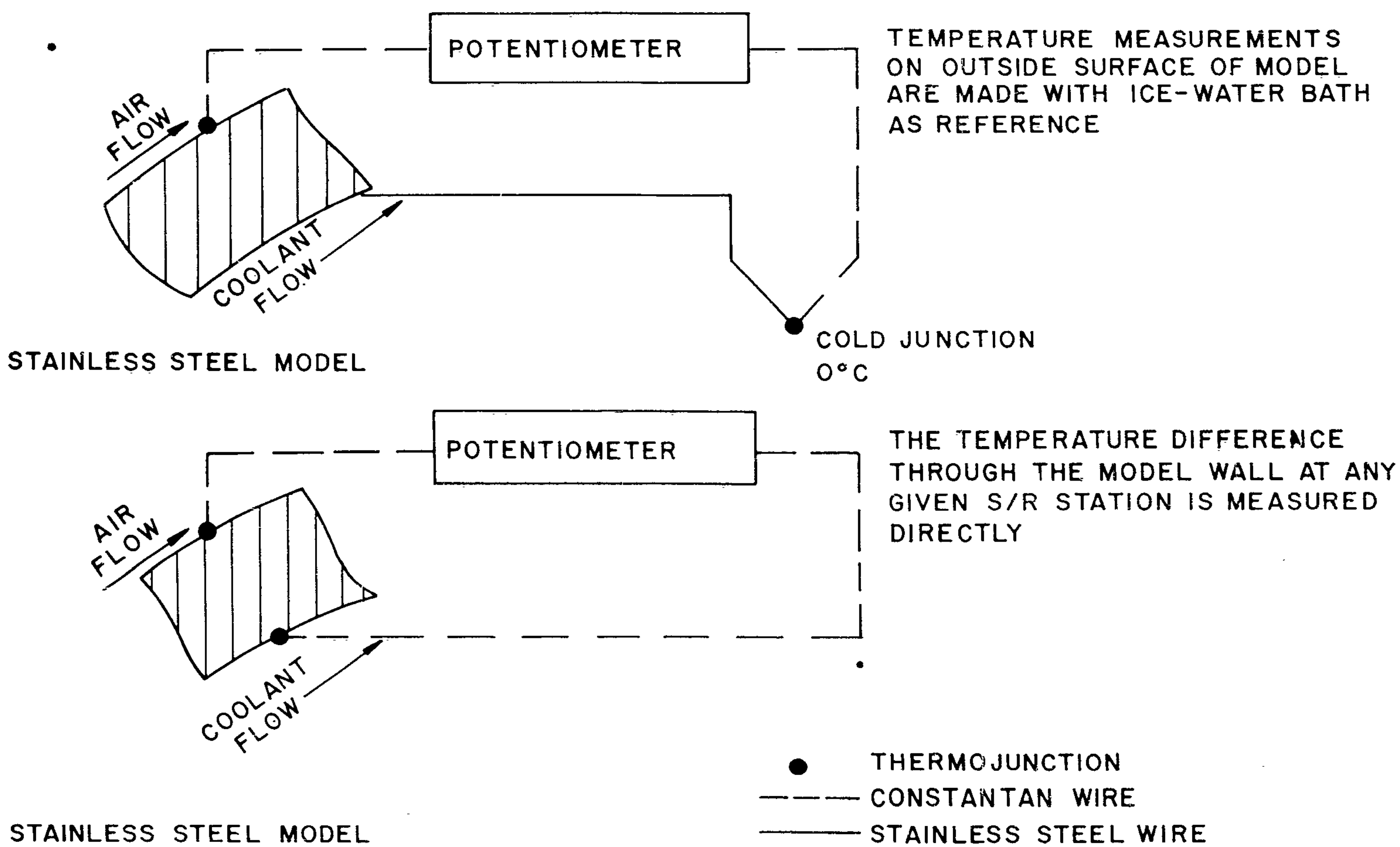

FIG. 3 SCHEMATIC DIAGRAM OF THERMOCOUPLE WIRING

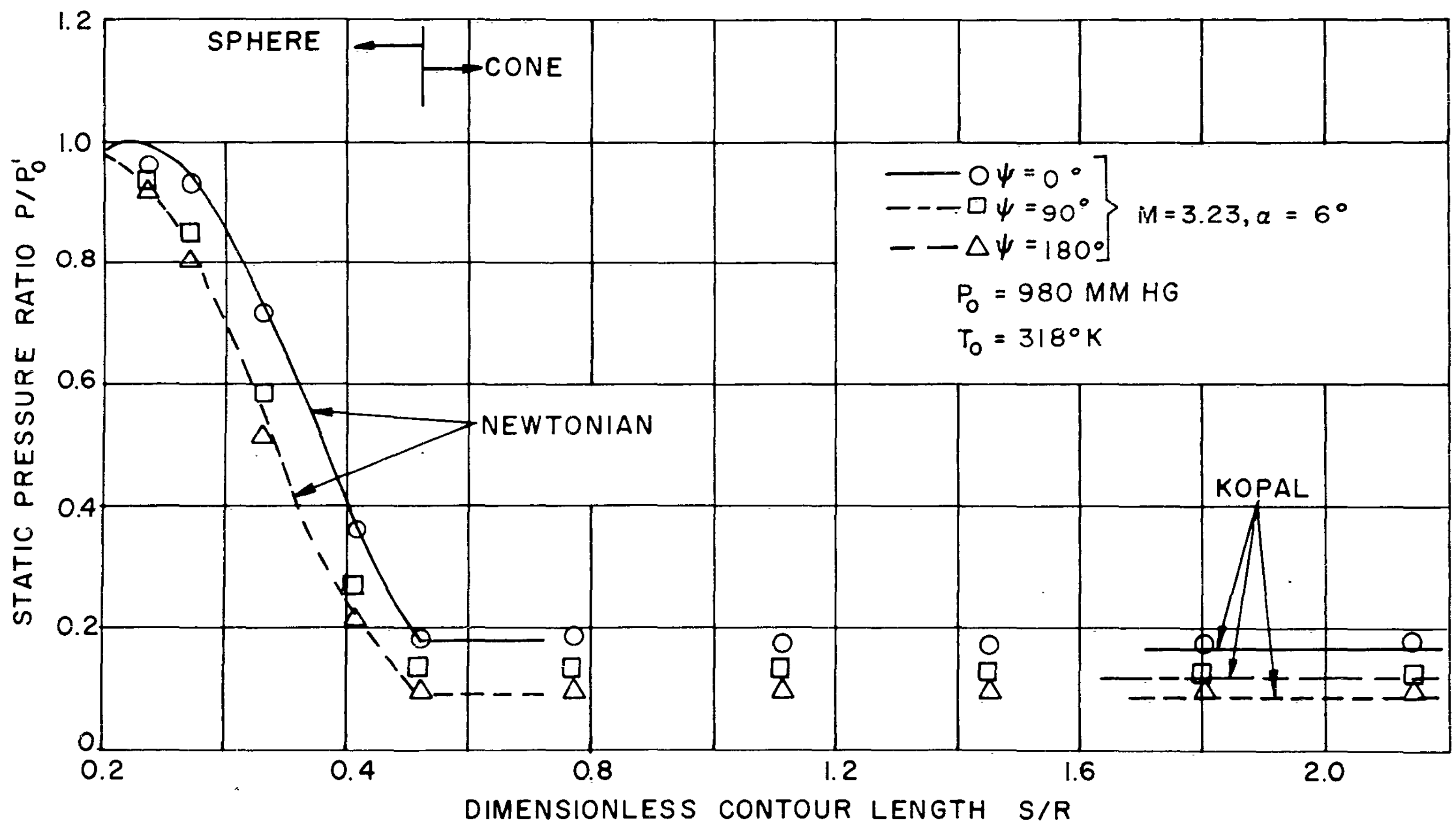

FIG. 4 SURFACE PRESSURE DISTRIBUTION OVER THE SPHERE-CONE MODEL AT M = 3.23, α = 6°

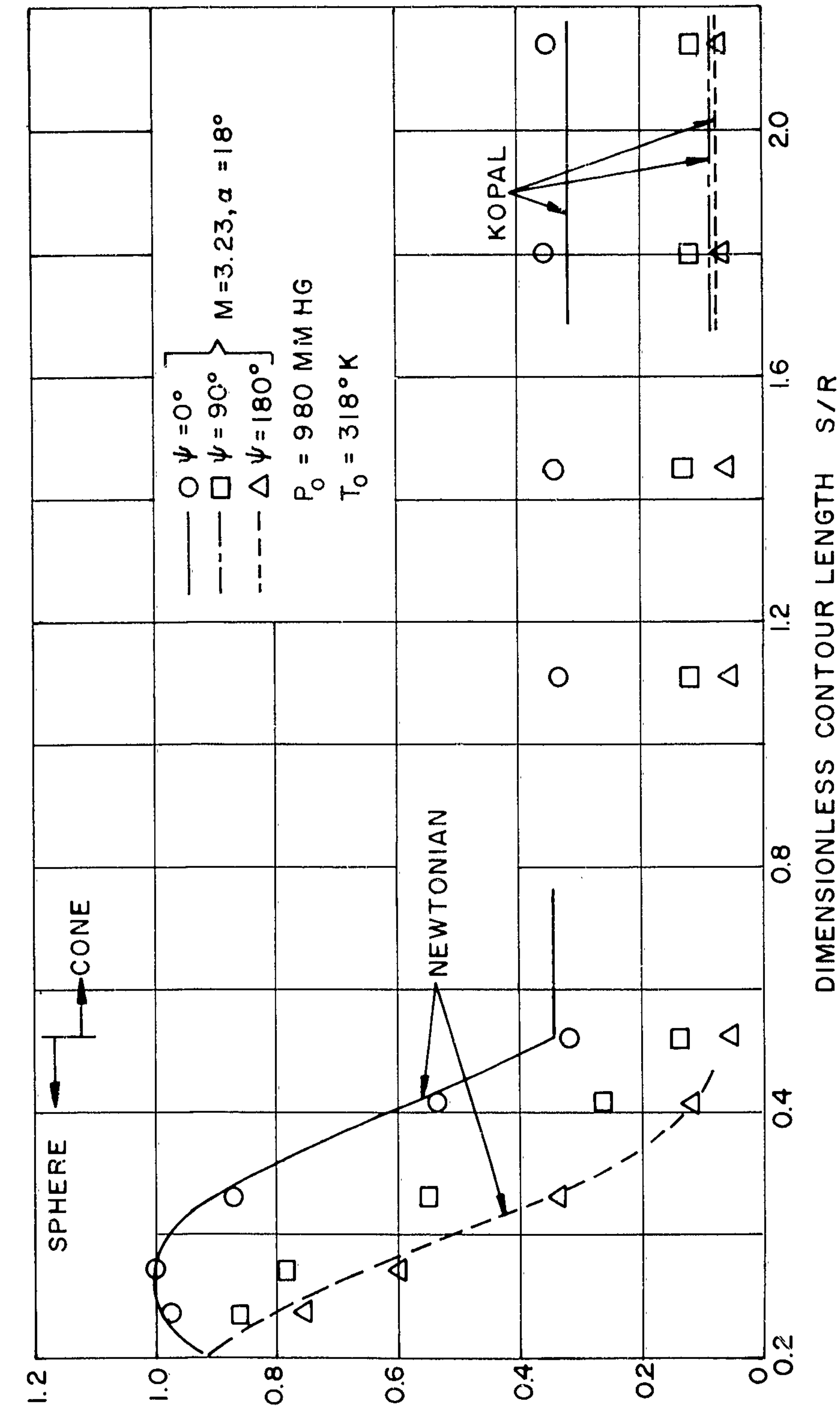

FIG. 5 SURFACE PRESSURE DISTRIBUTION OVER THE SPHERE-CONE MODEL AT M=3.23, α=18°

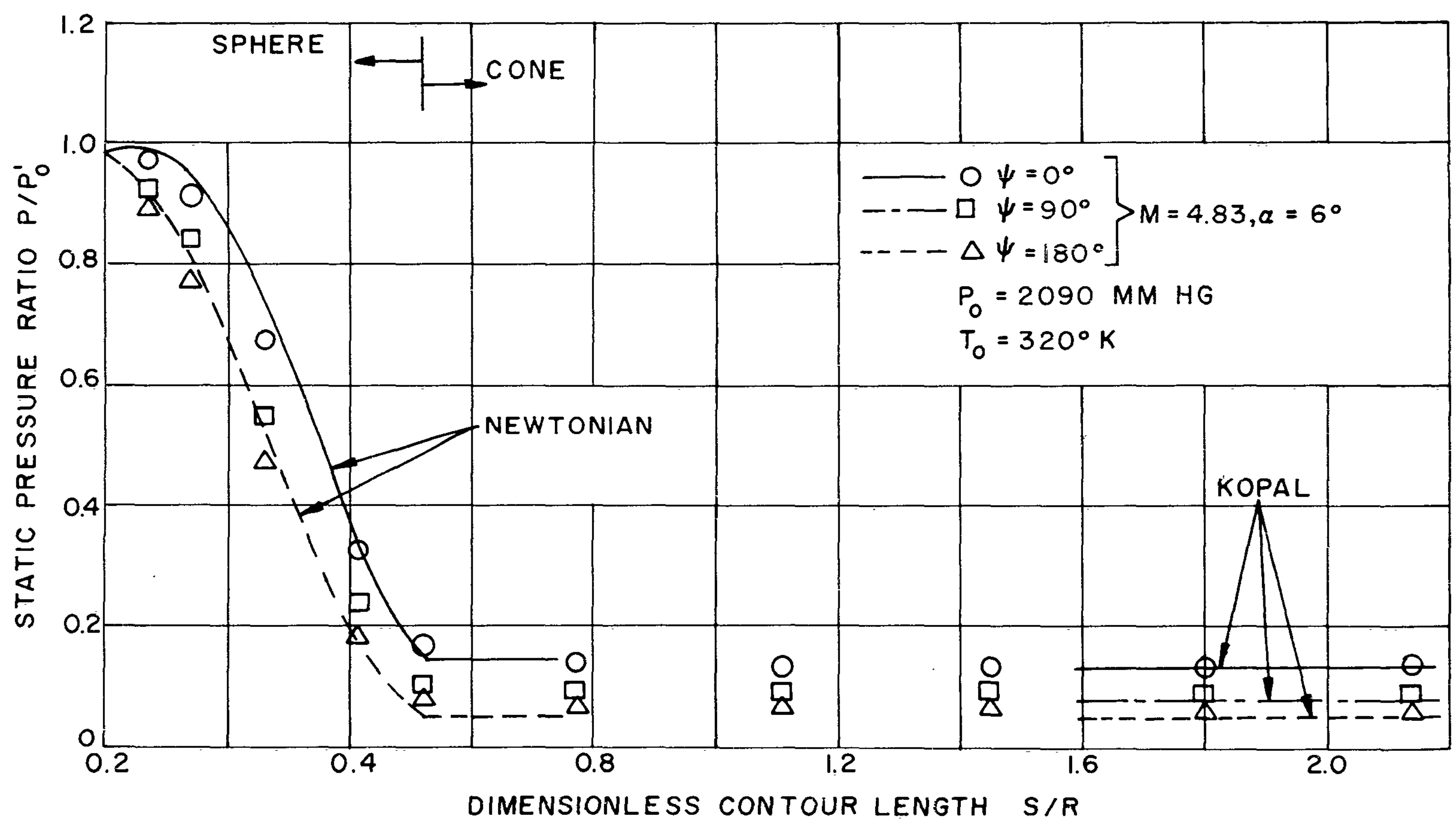

FIG. 6 SURFACE PRESSURE DISTRIBUTION OVER THE SPHERE-CONE MODEL AT $M = 4.83, \alpha = 6°$

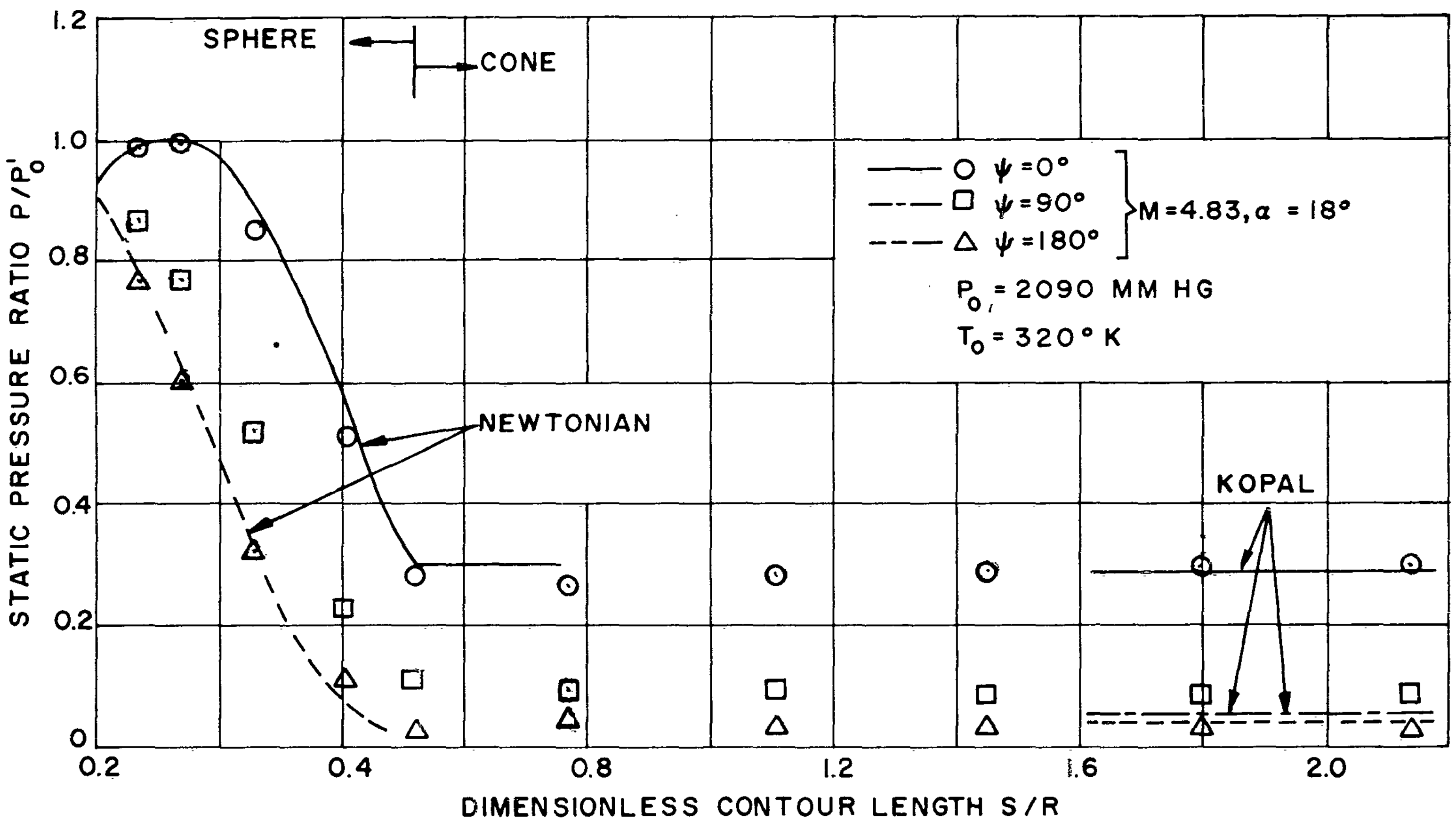

FIG. 7 SURFACE PRESSURE DISTRIBUTION OVER THE SPHERE-CONE MODEL AT $M = 4.83, \alpha = 18°$

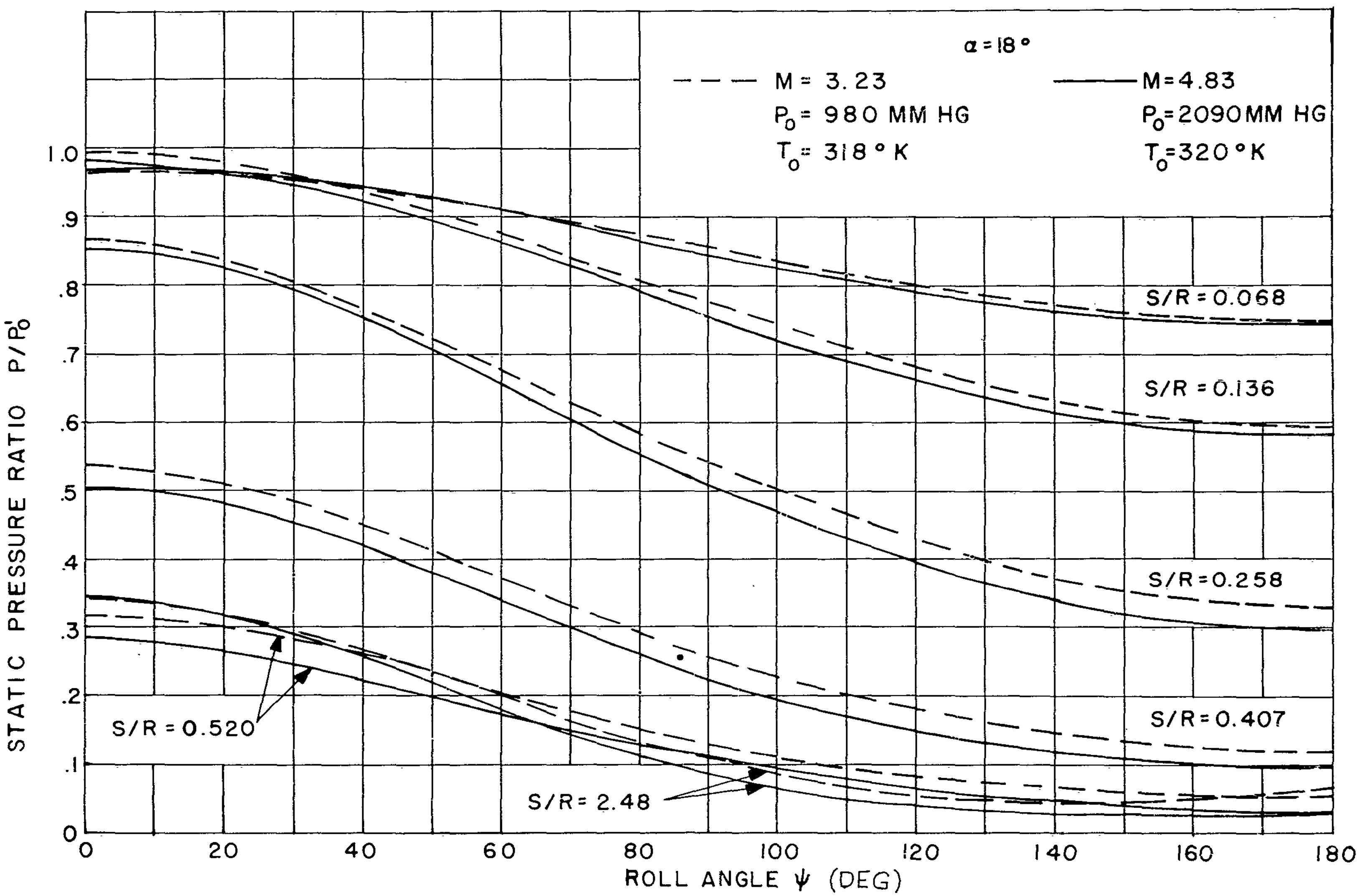

FIG. 8 COMPARISON BETWEEN THE M = 3.23 AND M = 4.83 SURFACE PRESSURE DISTRIBUTION OVER THE SPHERE–CONE MODEL AT α = 18°

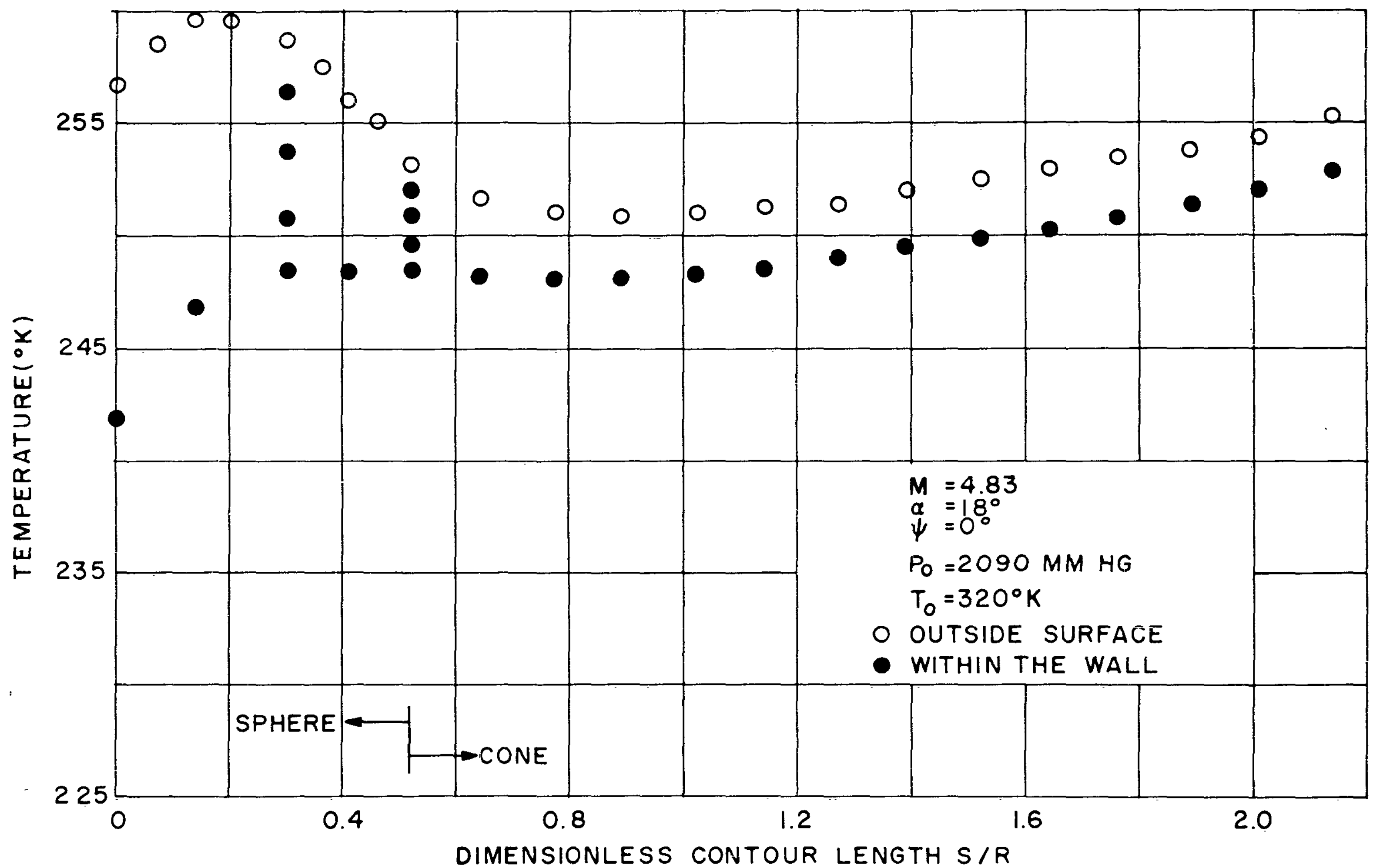

FIG. 9 THE MEASURED INTERNAL AND EXTERNAL WALL TEMPERATURE DISTRIBUTION ON THE SPHERE-CONE MODEL AT M =4.83, α =18° AND ψ =0°

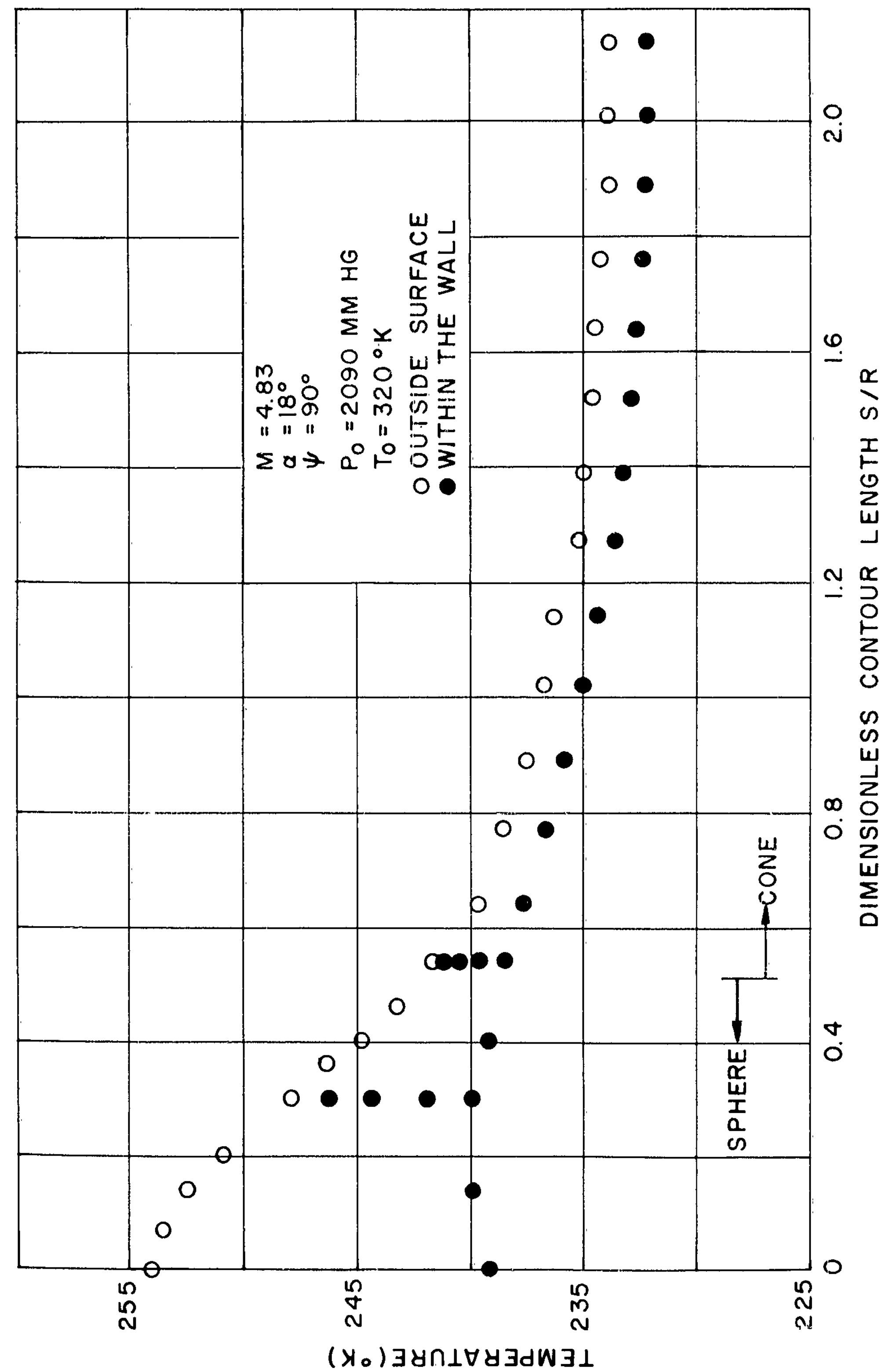

FIG. 10 THE MEASURED INTERNAL AND EXTERNAL WALL TEMPERATURE DISTRIBUTION ON THE SPHERE-CONE MODEL AT M = 4.83, α = 18° AND ψ = 90°

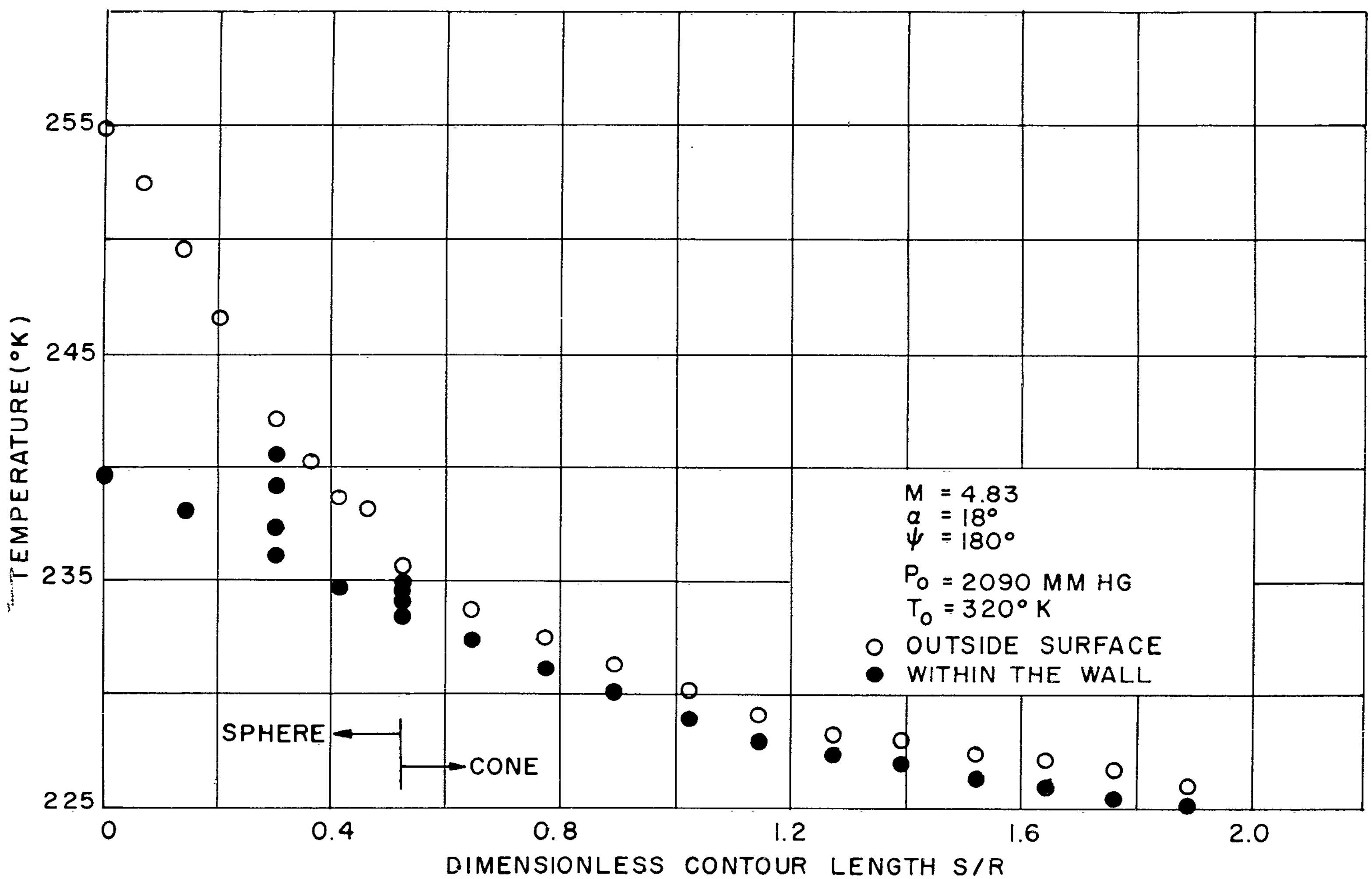

FIG. 11 THE MEASURED INTERNAL AND EXTERNAL WALL TEMPERATURE DISTRIBUTION ON THE SPHERE-CONE MODEL AT M = 4.83, $\alpha = 18°$ AND $\psi = 180°$

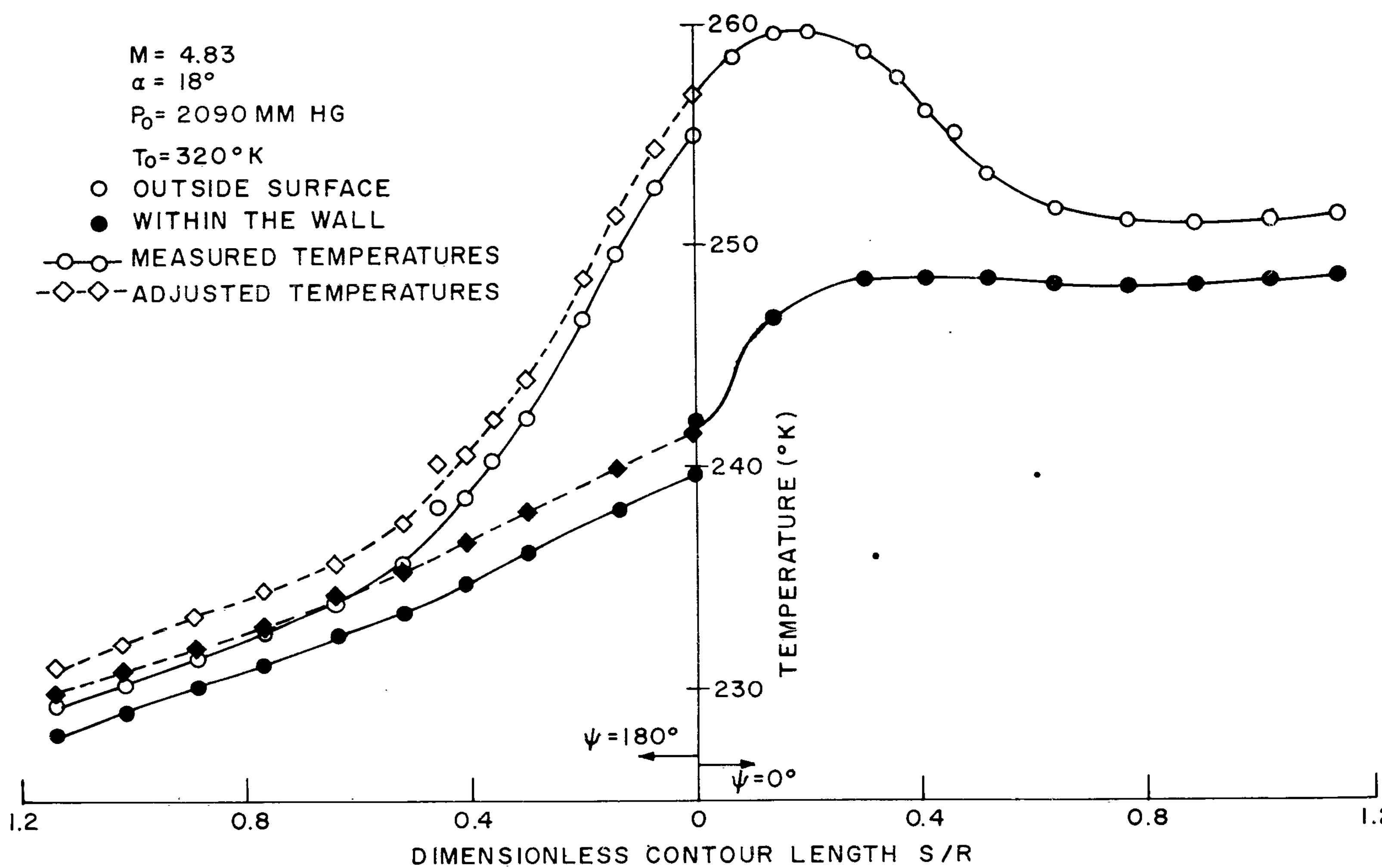

FIG. 12 THE MEASURED AND ADJUSTED INTERNAL AND EXTERNAL WALL TEMPERATURE DISTRIBUTIONS ON THE SPHERE–CONE MODEL AT $M = 4.83$, $\alpha = 18°$, AND $\psi = 0°$, AND 180°

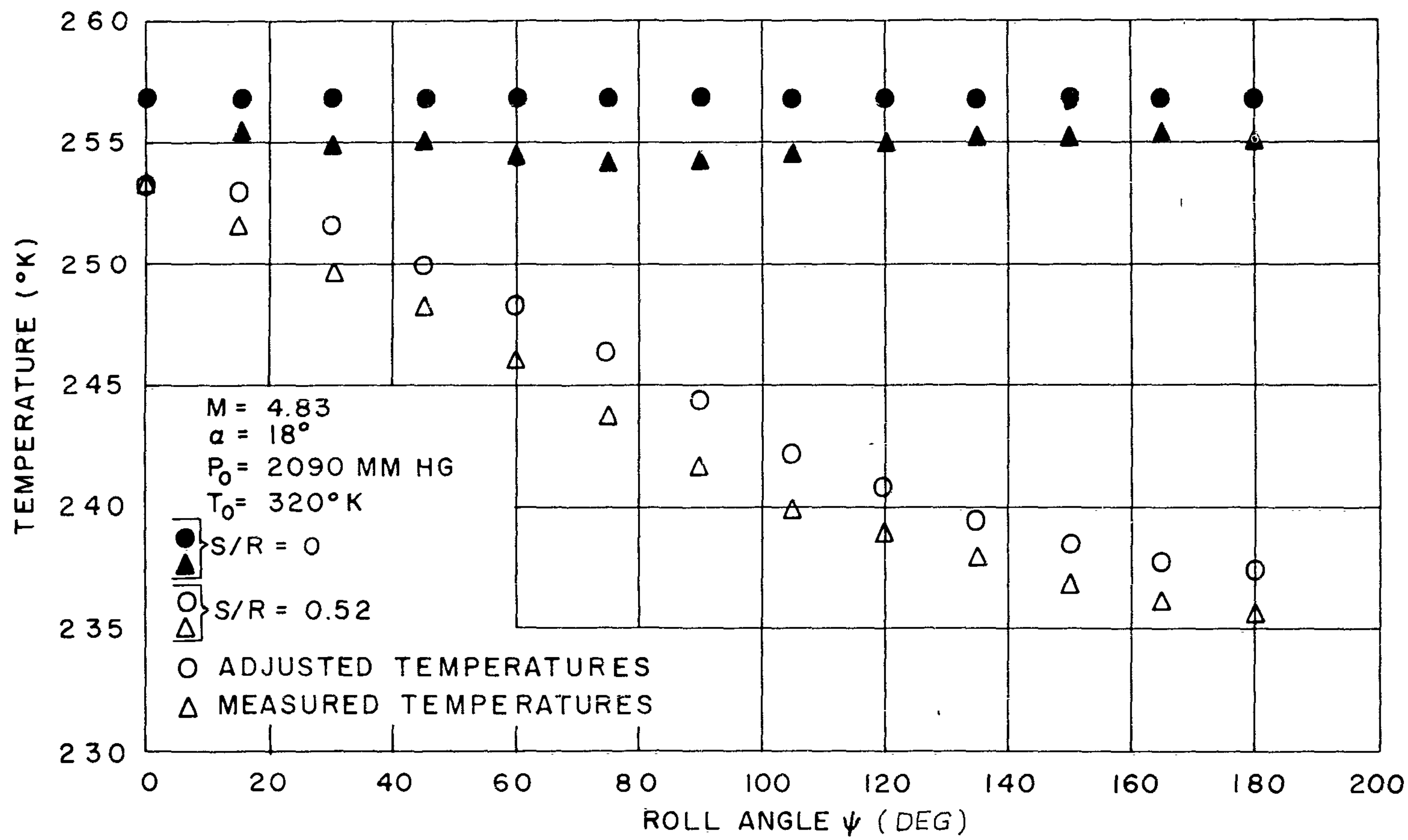

FIG. 13 COMPARISON BETWEEN ADJUSTED AND MEASURED TEMPERATURES ON THE SURFACE OF THE SPHERE-CONE MODEL AT $M = 4.83$, $\alpha = 18°$, AND $S/R = 0$, AND 0.52

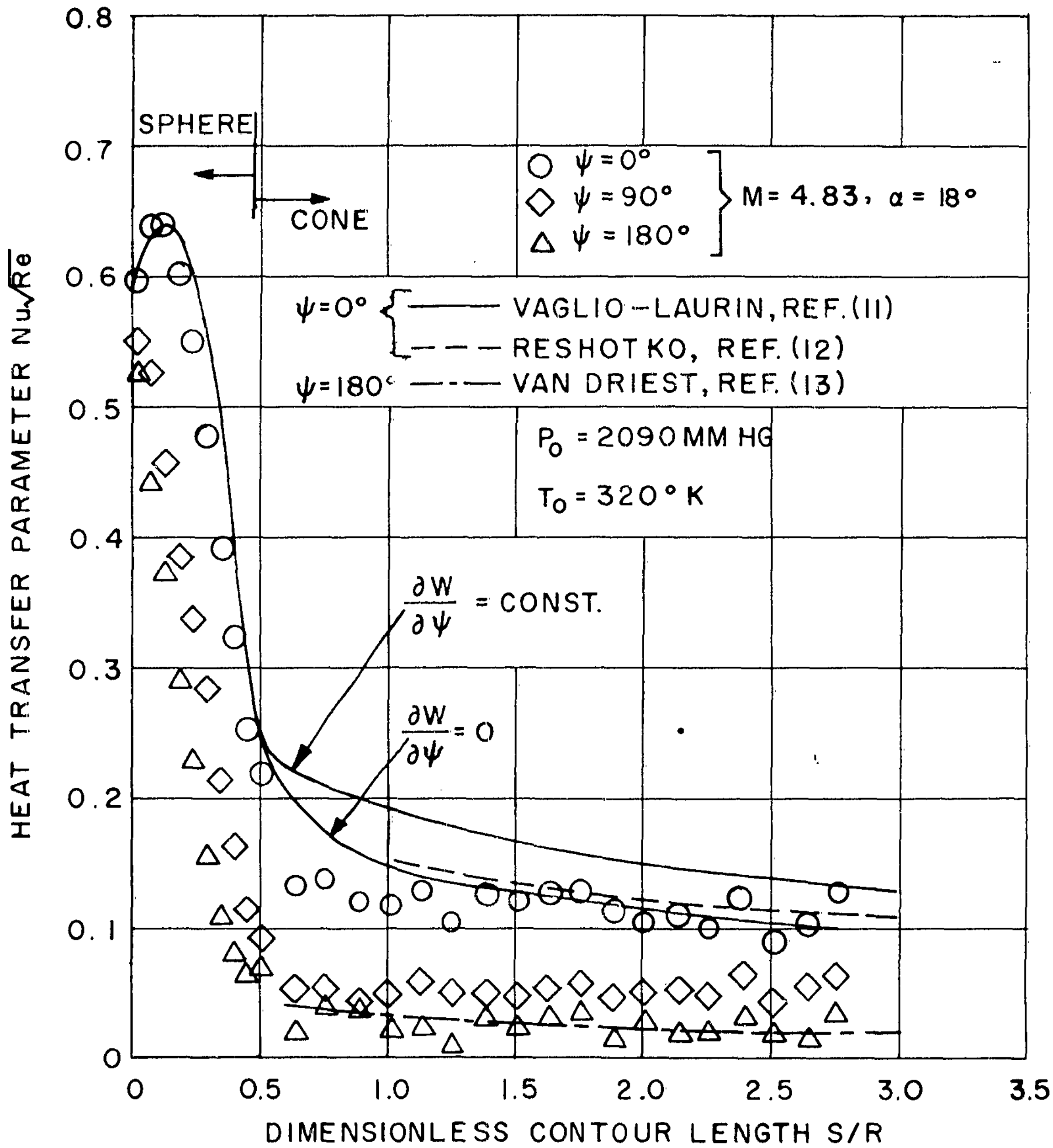

FIG. 14 HEAT-TRANSFER DISTRIBUTION TO THE SURFACE OF A SPHERE – CONE MODEL AT M = 4.83 AND $\alpha = 18°$

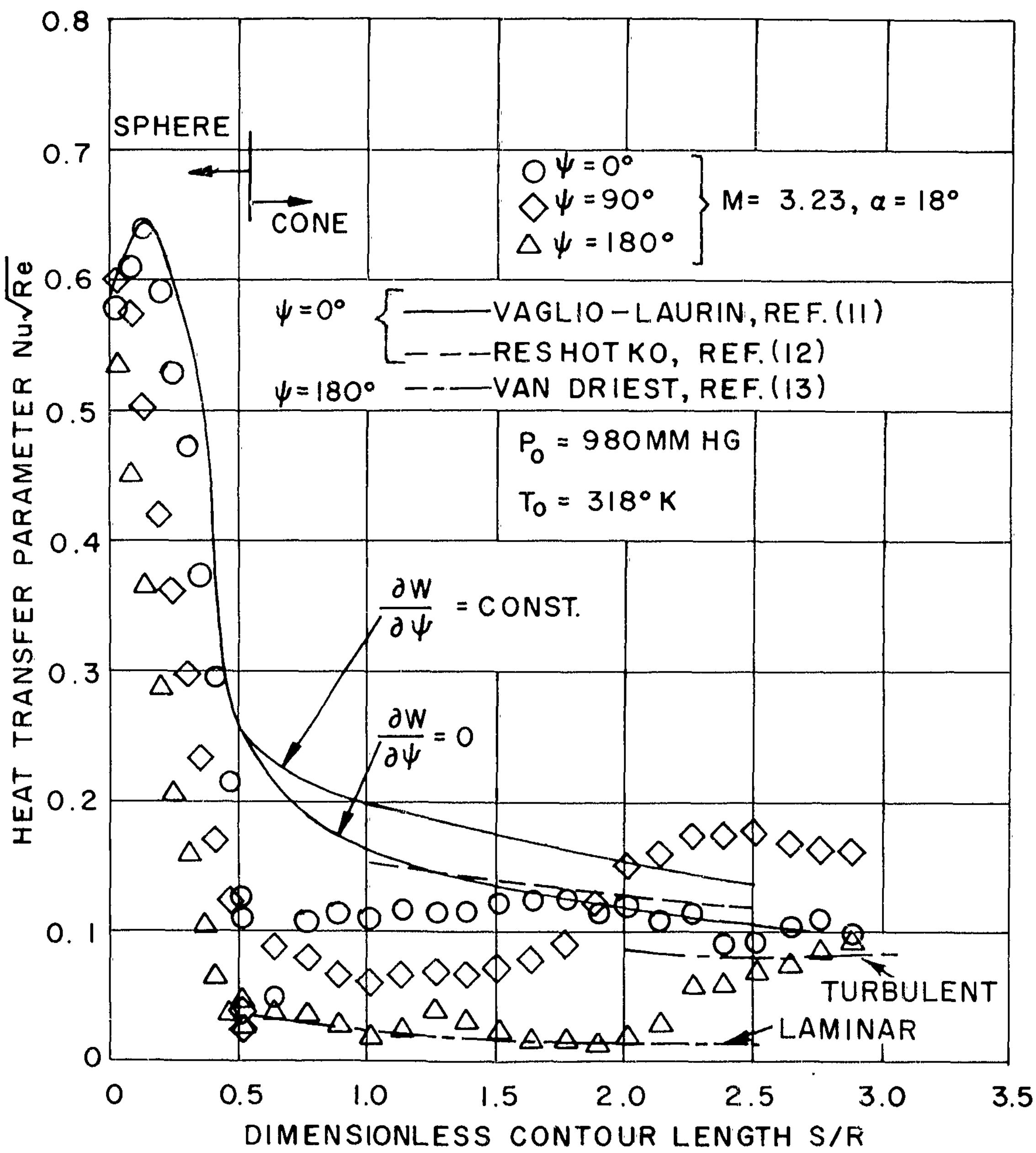

FIG. 15 HEAT-TRANSFER DISTRIBUTION TO THE SURFACE OF A SPHERE – CONE MODEL AT M = 3.23 AND α = 18°

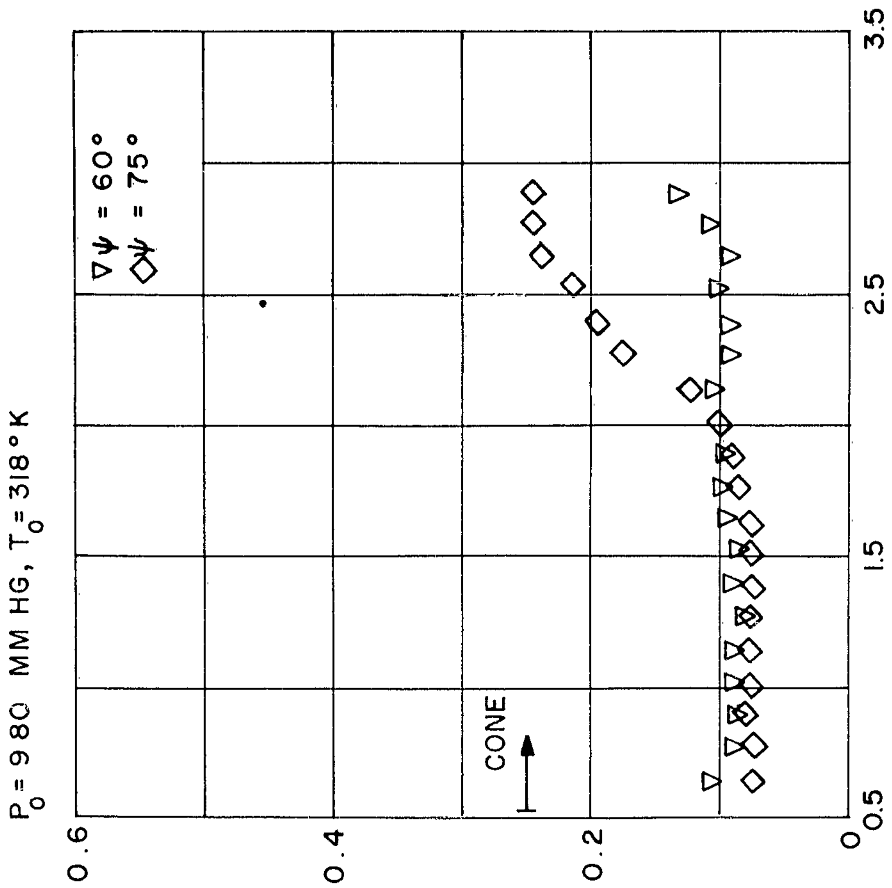

FIG. 17 HEAT TRANSFER VERSUS S/R FOR CONSTANT VALUES OF $\psi = 60°$ AND 75° AT M = 3.23 AND $\alpha = 18°$

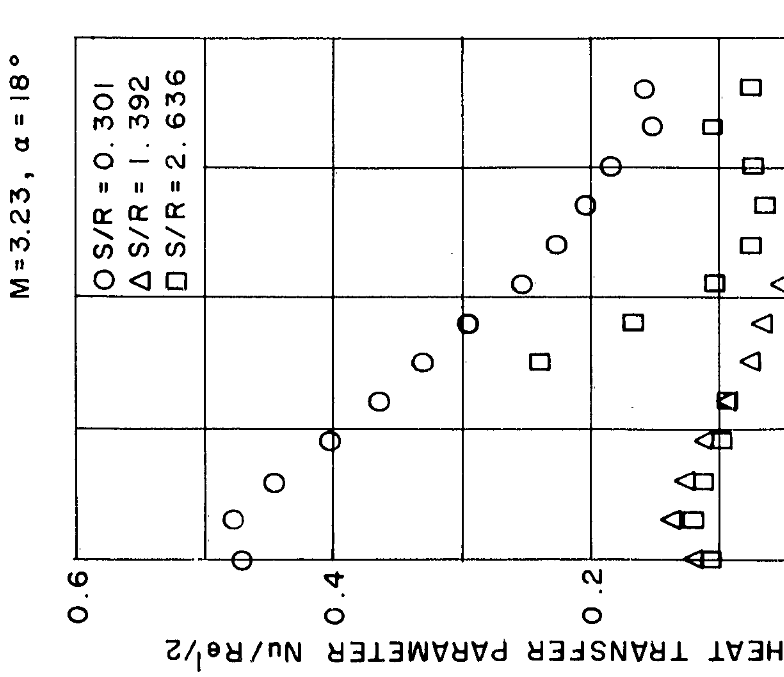

FIG. 16 HEAT TRANSFER VERSUS ROLL ANGLE FOR CONSTANT VALUES OF S/R = 0.301, 1.392 AND 2.636 AT M = 3.23 AND $\alpha = 18°$

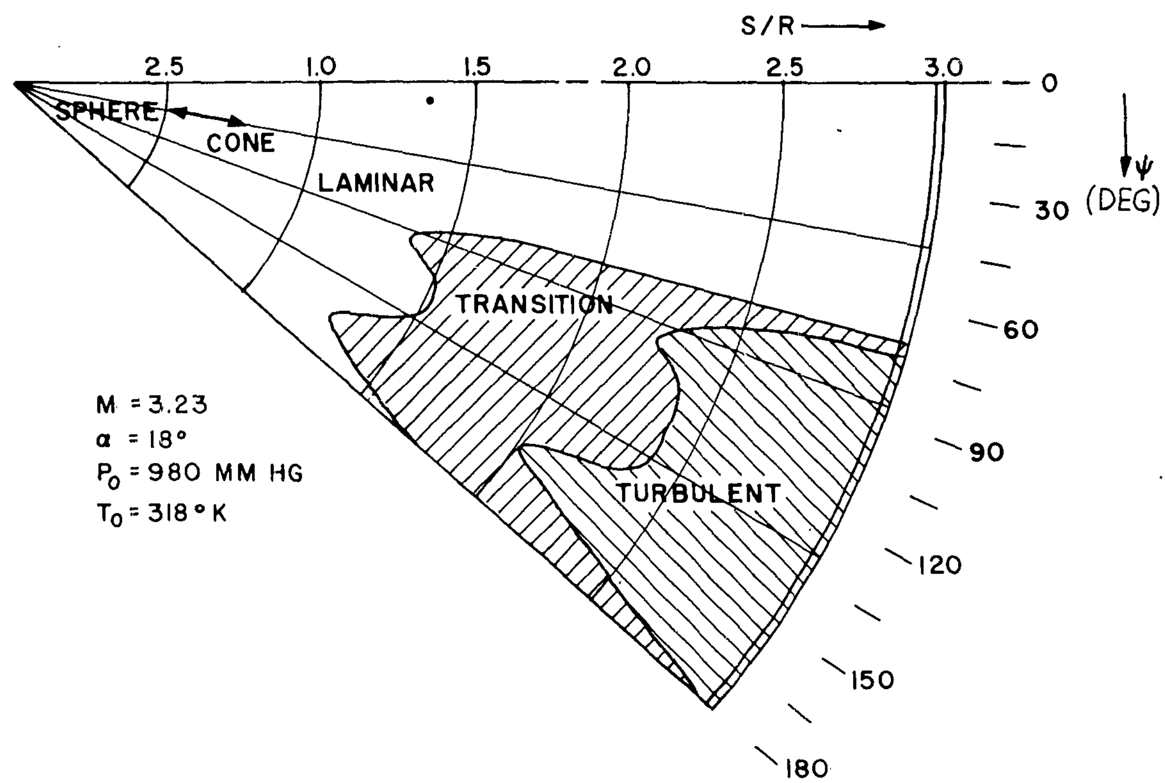

FIG. 18 THE REGIONS OF LAMINAR, TRANSITIONAL AND TURBULENT BOUNDARY LAYERS AT M = 3.23, α = 18°

Table 1

THERMOJUNCTION AND PRESSURE ORIFICE LOCATIONS

THERMOJUNCTION LOCATIONS						PRESSURE ORIFICE LOCATIONS			
SPHERE		CONE				SPHERE		CONE	
Station	S/R	Station	S/R	Station	S/R	Station	S/R	Station	S/R
1	0.	10	0.645	20	1.890	A	0.068	F	0.769
2	0.068	11	0.769	21	2.014	B	0.136	G	1.112
3	0.136	12	0.894	22	2.138	C	0.258	H	1.454
4	0.204	13	1.018	23	2.263	D	0.407	I	1.796
5	0.305	14	1.143	24	2.387	E	0.520	J	2.138
6	0.356	15	1.267	25	2.512			K	2.481
7	0.407	16	1.392	26	2.636				
8	0.455	17	1.516	27	2.761				
9	0.520	18	1.640	28	2.885				
		19	1.765	29	3.010				

Table 2

PRESSURE DISTRIBUTION ON SPHERE-CONE MODEL

MACH NUMBER = 4.8
ANGLE OF ATTACK = 18.0 DEGREES
SUPPLY PRESSURE = 2090.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

	DIMENSIONLESS CONTOUR LENGTH										
	0.068	0.136	0.258	0.407	0.520	0.769	1.112	1.454	1.796	2.138	2.481
ROLL ANGLE	(LOCAL STATIC PRESSURE)/(PITOT PRESSURE)										
0	0.9909	0.9949	0.8642	0.5128	0.2849	0.2658	0.2764	0.2903	0.2998	0.3039	0.3041
5	0.9905	0.9934	0.8612	0.5101	0.2834	0.2639	0.2736	0.2878	0.2981	0.3019	0.3023
10	0.9887	0.9888	0.8566	0.5052	0.2802	0.2602	0.2707	0.2839	0.2934	0.2969	0.2981
15	0.9865	0.9851	0.8476	0.4980	0.2749	0.2558	0.2646	0.2765	0.2861	0.2914	0.2920
20	0.9812	0.9778	0.8351	0.4862	0.2675	0.2487	0.2561	0.2661	0.2746	0.2807	0.2820
25	0.9777	0.9697	0.8201	0.4735	0.2594	0.2416	0.2473	0.2568	0.2638	0.2704	0.2715
30	0.9724	0.9607	0.8052	0.4596	0.2504	0.2313	0.2358	0.2450	0.2504	0.2575	0.2602
35	0.9656	0.9487	0.7859	0.4437	0.2384	0.2216	0.2240	0.2314	0.2367	0.2436	0.2462
40	0.9595	0.9350	0.7650	0.4239	0.2274	0.2076	0.2086	0.2143	0.2184	0.2272	0.2277
45	0.9531	0.9198	0.7434	0.4012	0.2096	0.1960	0.1930	0.1971	0.2033	0.2069	0.2081
50	0.9465	0.9049	0.7217	0.3865	0.2013	0.1894	0.1801	0.1852	0.1879	0.1932	0.1966
55	0.9382	0.8906	0.6985	0.3675	0.1896	0.1761	0.1681	0.1706	0.1723	0.1764	0.1806
60	0.9282	0.8724	0.6724	0.3471	0.1759	0.1644	0.1541	0.1547	0.1551	0.1585	0.1622
65	0.9193	0.8566	0.6487	0.3266	0.1642	0.1519	0.1429	0.1409	0.1398	0.1419	0.1449
70	0.9094	0.8390	0.6230	0.3069	0.1525	0.1405	0.1321	0.1280	0.1260	0.1273	0.1292
75	0.9003	0.8222	0.5995	0.2881	0.1412	0.1300	0.1205	0.1153	0.1121	0.1133	0.1151
80	0.8903	0.8038	0.5742	0.2699	0.1299	0.1202	0.1100	0.1051	0.0999	0.1001	0.1024
85	0.8803	0.7860	0.5480	0.2504	0.1187	0.1116	0.1017	0.0940	0.0887	0.0884	0.0906
90	0.8705	0.7652	0.5216	0.2331	0.1058	0.1031	0.0907	0.0809	0.0784	0.0762	0.0782
95	0.8617	0.7489	0.5004	0.2131	0.1133	0.0994	0.0786	0.0691	0.0657	0.0647	0.0654
100	0.8526	0.7339	0.4808	0.2043	0.1062	0.0941	0.0731	0.0648	0.0606	0.0585	0.0608
105	0.8436	0.7181	0.4622	0.1910	0.0997	0.0877	0.0694	0.0594	0.0557	0.0533	0.0545
110	0.8360	0.7027	0.4454	0.1788	0.0931	0.0816	0.0640	0.0557	0.0496	0.0471	0.0474
115	0.8272	0.6877	0.4263	0.1668	0.0867	0.0762	0.0601	0.0510	0.0440	0.0420	0.0422
120	0.8184	0.6729	0.4092	0.1563	0.0640	0.0711	0.0564	0.0472	0.0411	0.0376	0.0386
125	0.8111	0.6599	0.3933	0.1466	0.0589	0.0674	0.0525	0.0433	0.0372	0.0347	0.0337
130	0.8045	0.6484	0.3780	0.1378	0.0549	0.0638	0.0489	0.0403	0.0339	0.0306	0.0222
135	0.7982	0.6369	0.3648	0.1295	0.0506	0.0604	0.0449	0.0362	0.0318	0.0286	0.0186
140	0.7943	0.6294	0.3565	0.1229	0.0464	0.0581	0.0411	0.0322	0.0291	0.0256	0.0146
145	0.7892	0.6216	0.3471	0.1178	0.0444	0.0564	0.0393	0.0322	0.0290	0.0261	0.0240
150	0.7855	0.6145	0.3399	0.1133	0.0422	0.0545	0.0388	0.0320	0.0288	0.0264	0.0247
155	0.7818	0.6098	0.3320	0.1092	0.0408	0.0542	0.0386	0.0325	0.0300	0.0276	0.0249
160	0.7791	0.6045	0.3266	0.1063	0.0391	0.0525	0.0384	0.0330	0.0305	0.0286	0.0252
165	0.7765	0.6003	0.3227	0.1033	0.0376	0.0521	0.0383	0.0337	0.0310	0.0293	0.0259
170	0.7755	0.5979	0.3201	0.1014	0.0359	0.0515	0.0381	0.0257	0.0317	0.0298	0.0268
175	0.7743	0.5969	0.3178	0.1001	0.0347	0.0501	0.0381	0.0257	0.0320	0.0301	0.0283
180	0.7742	0.5966	0.3176	0.0995	0.0256	0.0470	0.0369	0.0261	0.0325	0.0317	0.0290

Table 2 (cont'd.)

PRESSURE DISTRIBUTION ON SPHERE-CONE MODEL

MACH NUMBER = 3.2
ANGLE OF ATTACK = 18.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

	DIMENSIONLESS CONTOUR LENGTH										
	0.068	0.136	0.258	0.407	0.520	0.769	1.112	1.454	1.796	2.138	2.481
ROLL ANGLE	(LOCAL STATIC PRESSURE)/(PITOT PRESSURE)										
0	0.9682	0.9956	0.8663	0.5366	0.3154		0.3282	0.3386	0.3545	0.3503	0.3439
5	0.9664	0.9956	0.8643	0.5355	0.3158		0.3260	0.3337	0.3523	0.3483	0.3403
10	0.9651	0.9943	0.8557	0.5304	0.3125		0.3229	0.3293	0.3474	0.3434	0.3359
15	0.9624	0.9870	0.8469	0.5204	0.3070		0.3180	0.3224	0.3403	0.3364	0.3291
20	0.9589	0.9777	0.8351	0.5094	0.3006		0.3103	0.3143	0.3295	0.3255	0.3180
25	0.9554	0.9671	0.8201	0.4964	0.2930		0.2983	0.3034	0.3165	0.3127	0.3074
30	0.9523	0.9585	0.8031	0.4840	0.2835		0.2855	0.2908	0.3001	0.2997	0.2975
35	0.9485	0.9487	0.7861	0.4720	0.2767		0.2751	0.2791	0.2869	0.2873	0.2866
40	0.9401	0.9341	0.7638	0.4506	0.2619		0.2572	0.2581	0.2692	0.2705	0.2694
45	0.9339	0.9209	0.7450	0.4334	0.2504		0.2422	0.2469	0.2526	0.2577	0.2537
50	0.9280	0.9081	0.7249	0.4128	0.2360		0.2285	0.2303	0.2356	0.2427	0.2360
55	0.9187	0.8915	0.6999	0.3907	0.2203		0.2139	0.2152	0.2203	0.2256	0.2177
60	0.9094	0.8738	0.6754	0.3706	0.2053		0.1971	0.2000	0.2044	0.2091	0.1996
65	0.8992	0.8575	0.6513	0.3529	0.1947		0.1836	0.1861	0.1890	0.1916	0.1801
70	0.8926	0.8418	0.6301	0.3337	0.1799		0.1708	0.1726	0.1759	0.1750	0.1653
75	0.8846	0.8267	0.6091	0.3167	0.1682		0.1554	0.1613	0.1593	0.1582	0.1492
80	0.8747	0.8113	0.5887	0.2994	0.1567		0.1439	0.1485	0.1461	0.1452	0.1375
85	0.8641	0.7943	0.5669	0.2802	0.1445		0.1308	0.1370	0.1317	0.1328	0.1229
90	0.8537	0.7739	0.5425	0.2590	0.1302		0.1162	0.1260	0.1162	0.1154	0.1072
95	0.8449	0.7589	0.5255	0.2482	0.1213		0.1074	0.1138	0.1039	0.1043	0.0950
100	0.8336	0.7417	0.5039	0.2334	0.1151		0.1001	0.1034	0.0944	0.0957	0.0853
105	0.8274	0.7257	0.4835	0.2186	0.1063		0.0910	0.0959	0.0869	0.0869	0.0758
110	0.8177	0.7103	0.4650	0.2069	0.0972		0.0835	0.0895	0.0796	0.0791	0.0676
115	0.8080	0.6959	0.4464	0.1936	0.0906		0.0769	0.0840	0.0738	0.0723	0.0599
120	0.8007	0.6820	0.4303	0.1817	0.0846		0.0707	0.0785	0.0694	0.0654	0.0535
125	0.7918	0.6674	0.4139	0.1722	0.0802		0.0650	0.0738	0.0636	0.0608	0.0480
130	0.7819	0.6548	0.3976	0.1618	0.0731		0.0623	0.0654	0.0588	0.0559	0.0449
135	0.7757	0.6433	0.3848	0.1538	0.0698		0.0579	0.0608	0.0548	0.0535	0.0415
140	0.7693	0.6325	0.3706	0.1463	0.0659		0.0570	0.0614	0.0566	0.0548	0.0402
145	0.7615	0.6239	0.3596	0.1401	0.0619		0.0555	0.0577	0.0559	0.0548	0.0402
150	0.7567	0.6150	0.3514	0.1357	0.0568		0.0559	0.0577	0.0559	0.0559	0.0440
155	0.7545	0.6095	0.3454	0.1315	0.0568		0.0579	0.0586	0.0572	0.0579	0.0473
160	0.7503	0.6038	0.3399	0.1260	0.0552		0.0577	0.0586	0.0586	0.0623	0.0517
165	0.7470	0.5989	0.3348	0.1224	0.0522		0.0583	0.0592	0.0601	0.0659	0.0552
170	0.7461	0.5947	0.3313	0.1218	0.0524		0.0586	0.0594	0.0625	0.0683	0.0590
175	0.7461	0.5940	0.3293	0.1207	0.0522		0.0586	0.0606	0.0625	0.0692	0.0619
180	0.7461	0.5940	0.3293	0.1176	0.0510		0.0575	0.0588	0.0639	0.0692	0.0621

Table 2 (cont'd.)

PRESSURE DISTRIBUTION ON SPHERE-CONE MODEL

MACH NUMBER = 3.2
ANGLE OF ATTACK = 6.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

DIMENSIONLESS CONTOUR LENGTH

(LOCAL STATIC PRESSURE)/(PITOT PRESSURE)

ROLL ANGLE	0.068	0.136	0.258	0.407	0.520	0.769	1.112	1.454	1.796	2.138	2.481
0	0.9624	0.9310	0.7165	0.3593	0.1817	0.1843	0.1757	0.1741	0.1777	0.1808	0.1710
5	0.9609	0.9277	0.7143	0.3587	0.1812	0.1834	0.1750	0.1737	0.1768	0.1794	0.1699
10	0.9596	0.9224	0.7094	0.3571	0.1806	0.1817	0.1730	0.1728	0.1759	0.1783	0.1680
15	0.9569	0.9173	0.7054	0.3549	0.1799	0.1806	0.1722	0.1713	0.1746	0.1772	0.1671
20	0.9540	0.9114	0.6992	0.3516	0.1794	0.1792	0.1706	0.1695	0.1726	0.1752	0.1653
25	0.9505	0.9063	0.6928	0.3474	0.1788	0.1783	0.1680	0.1666	0.1706	0.1719	0.1631
30	0.9481	0.9003	0.6855	0.3448	0.1772	0.1761	0.1638	0.1640	0.1691	0.1691	0.1627
35	0.9454	0.8946	0.6787	0.3423	0.1757	0.1741	0.1618	0.1604	0.1677	0.1662	0.1600
40	0.9425	0.8860	0.6692	0.3372	0.1737	0.1710	0.1591	0.1571	0.1660	0.1627	0.1562
45	0.9401	0.8773	0.658.	0.3315	0.1719	0.1673	0.1562	0.1543	0.1627	0.1624	0.1534
50	0.9388	0.8720	0.6495	0.3253	0.1688	0.1631	0.1529	0.1525	0.1587	0.1587	0.1507
55	0.9388	0.8650	0.6378	0.3171	0.1629	0.1580	0.1485	0.1498	0.1549	0.1556	0.1472
60	0.9383	0.8601	0.6278	0.3112	0.1591	0.1536	0.1450	0.1459	0.1509	0.1525	0.1428
65	0.9392	0.8557	0.6188	0.3059	0.1551	0.1509	0.1421	0.1421	0.1472	0.1492	0.1397
70	0.9392	0.8517	0.6082	0.2966	0.1512	0.1474	0.1379	0.1388	0.1450	0.1450	0.1357
75	0.9410	0.8539	0.6027	0.2895	0.1481	0.1450	0.1361	0.1350	0.1417	0.1370	0.1372
80	0.9397	0.8524	0.5962	0.2818	0.1454	0.1410	0.1344	0.1324	0.1372	0.1333	0.1339
85	0.9372	0.8480	0.5903	0.2747	0.1414	0.1377	0.1313	0.1291	0.1313	0.1286	0.1302
90	0.9350	0.8429	0.5834	0.2694	0.1368	0.1344	0.1288	0.1262	0.1269	0.1251	0.1260
95	0.9348	0.8393	0.5783	0.2639	0.1326	0.1291	0.1264	0.1220	0.1233	0.1211	0.1209
100	0.9341	0.8365	0.5724	0.2590	0.1291	0.1262	0.1231	0.1189	0.1211	0.1180	0.1187
105	0.9326	0.8340	0.5662	0.2530	0.1251	0.1231	0.1193	0.1145	0.1171	0.1158	0.1156
110	0.9322	0.8318	0.5587	0.2471	0.1218	0.1207	0.1158	0.1129	0.1136	0.1129	0.1125
115	0.9306	0.8294	0.5518	0.2422	0.1171	0.1173	0.1120	0.1114	0.1123	0.1105	0.1109
120	0.9291	0.8256	0.5441	0.2373	0.1158	0.1154	0.1109	0.1101	0.1101	0.1083	0.1081
125	0.9286	0.8219	0.5383	0.2336	0.1143	0.1123	0.1083	0.1059	0.1081	0.1050	0.1048
130	0.9273	0.8161	0.5324	0.2285	0.1120	0.1090	0.1070	0.1036	0.1052	0.1041	0.1039
135	0.9255	0.8128	0.5266	0.2241	0.1092	0.1059	0.1017	0.1008	0.1034	0.1030	0.1030
140	0.9262	0.8113	0.5242	0.2265	0.1094	0.1056	0.1012	0.1014	0.1045	0.1032	0.1025
145	0.9246	0.8080	0.5204	0.2270	0.1076	0.1054	0.0992	0.1008	0.1023	0.1014	0.1008
150	0.9231	0.8060	0.5176	0.2254	0.1065	0.1039	0.0970	0.0988	0.1012	0.1012	0.1008
155	0.9218	0.8038	0.5151	0.2243	0.1043	0.1023	0.0952	0.0970	0.1006	0.1008	0.1008
160	0.9196	0.8015	0.5138	0.2217	0.1021	0.1008	0.0955	0.0970	0.1001	0.1003	0.1008
165	0.9198	0.7993	0.5131	0.2163	0.1003	0.0997	0.0957	0.0970	0.1006	0.0999	0.1003
170	0.9187	0.7993	0.5120	0.2172	0.0986	0.0979	0.0957	0.0970	0.1006	0.0997	0.0994
175	0.9187	0.7993	0.5109	0.2164	0.0983	0.0972	0.0948	0.0970	0.1006	0.0992	0.0990
180	0.9187	0.7993	0.5109	0.2159	0.0972	0.0972	0.0944	0.0957	0.0992	0.0988	0.0988

Table 2 (cont'd.)

PRESSURE DISTRIBUTION ON SPHERE-CONE MODEL

MACH NUMBER = 4.8
ANGLE OF ATTACK = 6.0 DEGREES
SUPPLY PRESSURE = 2090.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

	DIMENSIONLESS CONTOUR LENGTH										
	0.068	0.136	0.258	0.407	0.520	0.769	1.112	1.454	1.796	2.138	2.481
ROLL ANGLE	(LOCAL STATIC PRESSURE)/(PITOT PRESSURE)										
0	0.9753	0.9191	0.6785	0.3292	0.1693	0.1429	0.1380	0.1356	0.1343	0.1389	0.1390
5	0.9740	0.9184	0.6772	0.3267	0.1666	0.1422	0.1378	0.1356	0.1340	0.1385	0.1382
10	0.9740	0.9171	0.6755	0.3260	0.1649	0.1421	0.1378	0.1358	0.1331	0.1375	0.1377
15	0.9725	0.9152	0.6728	0.3233	0.1637	0.1405	0.1372	0.1346	0.1323	0.1356	0.1353
20	0.9691	0.9123	0.6681	0.3187	0.1615	0.1377	0.1348	0.1336	0.1314	0.1343	0.1329
25	0.9664	0.9076	0.6613	0.3145	0.1584	0.1350	0.1329	0.1312	0.1292	0.1316	0.1302
30	0.9642	0.9044	0.6564	0.3105	0.1573	0.1319	0.1301	0.1291	0.1272	0.1291	0.1275
35	0.9625	0.9014	0.6493	0.3064	0.1541	0.1296	0.1280	0.1285	0.1258	0.1291	0.1262
40	0.9605	0.9003	0.6421	0.3007	0.1503	0.1262	0.1253	0.1252	0.1228	0.1248	0.1215
45	0.9586	0.8958	0.6363	0.2965	0.1473	0.1233	0.1235	0.1225	0.1187	0.1199	0.1177
50	0.9551	0.8902	0.6297	0.2921	0.1449	0.1206	0.1203	0.1198	0.1164	0.1162	0.1135
55	0.9515	0.8856	0.6181	0.2833	0.1383	0.1162	0.1157	0.1157	0.1123	0.1139	0.1091
60	0.9488	0.8792	0.6130	0.2797	0.1329	0.1149	0.1144	0.1139	0.1086	0.1100	0.1030
65	0.9448	0.8721	0.6024	0.2725	0.1297	0.1101	0.1106	0.1106	0.1059	0.1064	0.1012
70	0.9404	0.8650	0.5929	0.2662	0.1257	0.1064	0.1081	0.1074	0.1029	0.1024	0.0985
75	0.9404	0.8618	0.5856	0.2611	0.1245	0.1049	0.1034	0.1047	0.0995	0.0986	0.0934
80	0.9367	0.8559	0.5794	0.2574	0.1211	0.1029	0.1008	0.1015	0.0961	0.0956	0.0900
85	0.9321	0.8486	0.5669	0.2483	0.1181	0.0990	0.0978	0.0986	0.0937	0.0919	0.0870
90	0.9285	0.8421	0.5530	0.2400	0.1105	0.0959	0.0953	0.0941	0.0890	0.0885	0.0834
95	0.9252	0.8346	0.5488	0.2323	0.1069	0.0934	0.0903	0.0865	0.0801	0.0814	0.0772
100	0.9221	0.8301	0.5419	0.2280	0.1042	0.0910	0.0890	0.0872	0.0789	0.0791	0.0752
105	0.9186	0.8247	0.5345	0.2245	0.1022	0.0883	0.0865	0.0826	0.0764	0.0764	0.0723
110	0.9157	0.8174	0.5275	0.2186	0.0992	0.0846	0.0836	0.0812	0.0755	0.0743	0.0701
115	0.9120	0.8110	0.5204	0.2137	0.0971	0.0821	0.0824	0.0789	0.0736	0.0730	0.0694
120	0.9091	0.8057	0.5137	0.2093	0.0949	0.0802	0.0796	0.0774	0.0721	0.0709	0.0660
125	0.9076	0.7995	0.5073	0.2052	0.0917	0.0775	0.0769	0.0755	0.0706	0.0698	0.0640
130	0.9052	0.7948	0.5002	0.2007	0.0897	0.0757	0.0748	0.0750	0.0698	0.0672	0.0623
135	0.9020	0.7872	0.4948	0.1963	0.0863	0.0730	0.0745	0.0723	0.0669	0.0659	0.0613
140	0.8998	0.7834	0.4919	0.1965	0.0885	0.0743	0.0735	0.0716	0.0657	0.0633	0.0601
145	0.8990	0.7802	0.4889	0.1932	0.0865	0.0738	0.0711	0.0696	0.0644	0.0633	0.0586
150	0.8980	0.7770	0.4853	0.1902	0.0843	0.0725	0.0704	0.0691	0.0639	0.0617	0.0581
155	0.8963	0.7760	0.4841	0.1835	0.0831	0.0709	0.0699	0.0682	0.0620	0.0606	0.0569
160	0.8963	0.7743	0.4814	0.1873	0.0823	0.0699	0.0684	0.0671	0.0608	0.0601	0.0562
165	0.8963	0.7731	0.4804	0.1865	0.0807	0.0696	0.0681	0.0666	0.0608	0.0601	0.0562
170	0.8963	0.7726	0.4789	0.1853	0.0807	0.0696	0.0684	0.0660	0.0603	0.0601	0.0562
175	0.8963	0.7726	0.4789	0.1845	0.0802	0.0693	0.0679	0.0652	0.0601	0.0601	0.0562
180	0.8963	0.7726	0.4784	0.1838	0.0791	0.0682	0.0674	0.0633	0.0576	0.0591	0.0562

Table 3

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL, (NOSE SECTION)

MACH NUMBER = 4.82
ANGLE OF ATTACK = 18 DEGREES
SUPPLY PRESSURE = 2090 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.	0.	256.8	255.4	254.8	255.0	254.4	254.1	254.1	254.5	254.9	255.2	255.1	255.3	255.0
0.	0.500	242.0	240.4	240.3	239.9	239.8	239.3	239.2	240.0	240.0	240.7	240.7	240.2	239.7
0.068	0.	258.6	257.0	255.9	255.8	254.8	254.2	253.6	253.4	253.3	253.4	253.0	253.0	252.6
0.136	0.	259.7	257.9	256.6	256.1	254.7	253.6	252.5	252.0	251.3	250.9	250.3	250.0	249.6
0.136	0.500	246.8	243.9	242.9	242.2	241.0	240.4	239.9	239.7	239.2	239.3	238.6	238.2	238.1
0.204	0.	259.7	258.0	256.3	255.7	253.8	252.8	250.9	250.0	249.2	248.4	247.6	247.2	246.7
0.305	0.	258.8	256.9	255.3	254.2	252.1	249.9	248.0	246.5	245.4	244.4	243.4	242.7	242.2
0.305	0.500													
0.305	0.375	250.9	248.7	247.4	246.6	244.9	243.2	241.9	240.8	240.1	239.3	238.6	237.9	237.4
0.305	0.250	253.8	251.8	250.4	249.6	247.7	245.8	244.3	243.1	242.1	241.3	240.5	239.8	239.2
0.305	0.125	256.5	254.5	253.1	252.1	250.2	248.1	246.3	244.9	243.8	242.8	241.8	241.1	240.6
0.356	0.	257.6	255.8	254.1	252.8	250.4	248.5	246.4	244.8	243.7	242.5	241.4	240.7	240.3
0.407	0.	256.1	254.5	252.7	251.3	249.1	247.0	244.8	243.1	241.8	240.7	239.7	239.1	238.7
0.407	0.500	248.5	246.6	244.9	243.9	242.1	240.7	239.2	237.9	237.1	236.4	235.6	235.0	234.8
0.455	0.	255.1	253.3	251.4	250.0	247.8	245.5	243.3	242.0	240.5	239.8	233.9	238.3	238.2
0.520	0.	253.3	251.6	249.6	248.2	245.9	243.7	241.7	239.9	238.9	237.9	236.8	236.2	235.6
0.520	0.500	248.5	246.5	244.9	243.8	241.9	240.0	239.5	237.1	236.3	235.6	234.5	233.9	233.4
0.520	0.375	249.7	248.1	246.3	245.2	243.2	241.3	239.6	238.1	237.2	236.3	235.2	234.6	234.1
0.520	0.250	251.0	249.4	247.5	246.4	244.3	242.3	240.5	238.8	237.9	237.0	235.9	235.2	234.6
0.520	0.125	252.1	250.4	248.6	247.3	245.1	243.0	241.1	239.4	238.4	237.4	236.2	235.5	234.9

Table 3 (cont'd.)

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL, (CONE SECTION)

MACH NUMBER = 4.82
ANGLE OF ATTACK = 18 DEGREES
SUPPLY PRESSURE = 2090 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.645	0.	251.7	250.1	248.1	246.6	244.1	242.1	239.7	237.9	236.8	235.9	235.0	234.5	233.9
0.645	0.500	248.3	246.7	244.8	243.6	241.3	239.7	237.7	236.1	235.1	234.3	233.4	233.0	232.5
0.769	0.	251.2	249.8	247.6	246.0	243.4	241.1	238.6	236.8	235.6	234.7	233.9	233.4	232.6
0.769	0.500	248.1	246.6	244.5	243.1	240.8	238.8	236.6	235.1	234.0	233.1	232.3	231.8	231.1
0.894	0.	251.0	249.6	247.2	245.3	242.7	240.2	237.5	235.5	234.3	233.4	232.5	232.1	231.4
0.894	0.500	248.2	246.8	244.4	242.8	240.3	238.1	235.8	234.0	232.9	231.9	231.1	230.6	230.1
1.018	0.	251.1	249.7	247.1	245.1	242.2	239.4	236.7	234.6	233.4	232.1	231.4	230.8	230.2
1.018	0.500	248.4	246.9	244.3	242.4	239.8	237.3	235.0	233.1	231.9	230.7	230.0	229.5	229.0
1.143	0.	251.4	250.1	247.3	244.9	242.0	238.9	236.2	233.9	232.6	231.1	230.5	229.8	229.2
1.143	0.500	248.6	247.0	244.2	242.0	239.3	236.6	234.3	232.3	231.0	229.7	229.1	228.5	228.0
1.267	0.	251.5	250.2	247.2	244.6	241.3	238.2	235.1	233.0	231.6	230.2	229.5	228.8	228.3
1.267	0.500	249.1	247.5	244.4	242.0	239.0	236.3	233.6	231.8	230.4	229.1	228.5	227.9	227.4
1.392	0.	252.2	250.9	247.6	244.9	241.4	238.2	235.0	232.8	231.4	229.8	229.2	228.6	228.0
1.392	0.500	249.6	248.0	244.7	242.1	238.9	236.0	233.3	231.3	230.1	228.7	228.1	227.5	227.0
1.516	0.	252.6	251.3	247.8	244.9	241.2	237.9	234.6	232.3	230.7	229.3	228.7	228.1	227.4
1.516	0.500	250.0	248.3	244.8	242.1	238.7	235.7	232.9	230.7	229.4	228.1	227.5	226.9	226.3
1.640	0.	253.1	251.8	248.2	245.1	241.3	237.8	234.5	232.0	230.4	228.9	228.3	227.7	227.1
1.640	0.500	250.4	248.7	245.2	242.2	238.7	235.6	232.7	230.4	229.0	227.6	227.1	226.4	225.9
1.765	0.	253.6	252.1	248.5	245.2	241.3	237.7	234.3	231.7	229.9	228.5	227.9	227.3	226.7
1.765	0.500	250.9	249.1	245.3	242.2	238.7	235.4	232.4	230.1	228.4	227.1	226.6	226.0	225.4
1.890	0.	253.9	252.5	248.6	245.1	241.1	237.4	233.9	231.2	229.2	227.8	227.1	226.5	225.9
1.890	0.500	251.5	249.7	245.7	242.4	238.6	235.3	232.3	229.9	228.0	226.7	226.1	225.6	225.0
2.014	0.	254.5	253.0	249.0	245.3	241.2	237.4	233.9	231.1	229.0	227.6	226.9	226.3	225.7
2.014	0.500	252.1	250.2	246.0	242.5	238.7	235.3	232.2	229.7	227.7	226.5	225.9	225.3	224.7
2.138	0.	255.4	253.8	249.3	245.4	241.2	237.3	233.9	230.9	228.6	227.3	226.3	226.0	224.7
2.138	0.500	253.0	251.1	246.4	242.7	238.9	235.3	232.2	229.5	227.4	226.3	225.3	225.1	223.9
2.263	0.	256.6	254.8	250.0	245.7	241.4	237.3	233.8	230.7	228.4	227.0	226.0	225.8	223.9
2.263	0.500	254.4	252.2	247.1	243.0	239.0	235.3	232.1	229.4	227.2	226.0	225.1	224.8	222.9
2.387	0.	258.6	256.4	251.2	246.3	241.7	237.6	234.0	230.9	228.5	227.1	226.1	226.0	**225.6**
2.387	0.500	256.4	253.8	248.3	243.4	239.1	235.3	232.1	229.3	227.1	225.9	224.9	224.8	**224.4**
2.512	0.	260.1	258.1	252.3	246.8	241.9	237.5	233.9	230.7	228.3	227.0	225.9	225.8	**224.6**
2.512	0.500	258.5	256.1	249.8	244.2	239.7	235.6	232.3	229.4	227.2	226.0	225.1	225.0	**223.4**
2.636	0.	262.0	260.1	254.0	247.8	242.2	237.8	234.0	230.9	228.4	227.1	226.0	226.0	**225.6**
2.636	0.500	260.5	258.4	251.6	245.2	239.8	235.7	232.3	229.5	227.3	226.1	225.3	225.2	**224.6**
2.761	0.	263.6	261.6	255.5	249.0	242.8	238.1	234.4	231.3	228.8	227.6	226.6	226.7	226.3
2.761	0.500	262.4	260.3	253.5	246.3	240.3	235.9	232.5	229.7	227.5	226.4	225.6	225.6	225.0
2.885	0.	263.0	261.2	255.6	249.1	242.4	237.7	234.0	231.0	228.7	227.7	226.8	226.8	226.6
2.885	0.500	262.8	261.0	255.1	247.7	240.8	236.3	232.9	230.1	228.1	227.2	226.4	226.4	225.9
3.010	0.	263.3	261.7	256.5	250.8	243.7	238.8	235.2	232.4	230.1	229.4	228.5	228.5	228.2
3.010	0.375	262.0	260.4	255.1	249.4	241.9	237.2	233.8	231.3	229.2	228.5	227.7	227.6	227.2
3.010	0.250	262.3	260.7	255.3	249.6	242.3	237.5	234.1	231.4	229.2	228.5	227.8	227.7	227.3
3.010	0.125	262.7	261.1	255.9	250.1	243.0	238.1	234.6	231.8	229.5	228.8	227.9	227.9	227.5

Table 3 (cont'd.)

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL. (NOSE SECTION)

MACH NUMBER = 3.23
ANGLE OF ATTACK = 18 DEGREES
SUPPLY PRESSURE = 980 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.	0.	266.6	265.8	265.7	264.9	264.5	264.0	263.7	264.4	264.3	264.4	264.5	264.6	264.5
0.	0.500	246.0	246.0	248.0	245.5	245.1	245.5	244.5	244.7	244.7	245.6	245.7	244.8	244.2
0.068	0.	268.4	267.6	267.7	266.3	265.3	264.4	263.5	263.5	262.9	262.4	262.1	261.9	261.8
0.136	0.	269.8	268.9	268.5	266.7	265.3	263.7	262.3	261.5	260.9	260.1	259.4	259.1	258.7
0.136	0.500	254.9	254.4	252.7	251.6	250.3	249.1	247.9	248.0	247.6	247.3	246.6	246.1	246.0
0.204	0.	269.5	268.8	268.0	266.3	264.4	262.6	260.7	259.8	258.5	257.3	256.4	255.9	255.5
0.305	0.	268.6	267.9	266.6	264.3	262.1	260.0	257.7	256.4	254.6	253.2	252.0	251.1	250.8
0.305	0.500													
0.305	0.375	259.8	259.3	258.0	256.0	254.1	252.5	250.5	249.7	248.6	247.6	246.6	245.8	245.6
0.305	0.250	263.2	262.6	261.4	259.4	257.3	255.6	253.5	252.5	251.1	250.0	248.9	248.0	247.8
0.305	0.125	266.3	265.5	264.4	262.2	260.1	258.2	256.0	254.8	253.2	251.9	250.6	249.6	249.3
0.356	0.	267.3	266.7	265.5	263.1	260.6	258.5	256.0	254.4	252.6	251.0	250.0	249.1	248.8
0.407	0.	265.8	265.2	264.1	261.6	259.1	256.8	254.3	252.7	250.7	249.2	248.0	247.2	246.8
0.407	0.500	257.2	256.6	255.5	253.3	251.4	249.6	247.6	246.5	245.4	244.4	243.5	242.8	242.5
0.455	0.	264.6	264.0	262.8	260.2	257.7	255.3	252.9	251.1	249.1	247.7	246.8	246.4	246.0
0.520	0.	262.7	262.1	261.0	256.5	256.0	253.5	251.0	249.2	247.3	245.8	244.8	244.1	243.8
0.520	0.500	257.3	256.5	255.7	253.4	251.3	249.3	247.2	245.8	244.6	243.5	242.5	241.8	241.5
0.520	0.375	258.8	258.1	257.3	255.1	252.9	250.8	248.6	247.1	245.7	244.5	243.4	242.6	242.3
0.520	0.250	260.4	259.7	258.8	256.6	254.3	252.0	249.7	248.1	246.6	245.3	244.2	243.4	243.0
0.520	0.125	261.8	261.0	260.0	257.7	255.3	253.0	250.6	248.9	247.2	245.8	244.7	243.8	243.4

Table 3 (cont'd.)

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL. (CONE SECTION)

MACH NUMBER = 3.23
ANGLE OF ATTACK = 18 DEGREES
SUPPLY PRESSURE = 980 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.645	0.	261.3	260.8	259.7	257.2	254.6	252.0	249.4	247.4	245.4	244.1	243.0	242.4	242.1
0.645	0.500	257.4	256.7	255.8	253.6	251.3	249.1	246.9	245.3	243.8	242.7	241.7	240.9	240.7
0.769	0.	261.3	260.7	259.4	256.9	254.1	251.4	248.7	246.6	244.4	242.9	242.0	241.4	241.3
0.769	0.500	257.8	257.0	255.8	253.6	251.2	248.7	246.3	244.7	243.0	241.8	240.7	240.0	239.8
0.894	0.	261.5	260.8	259.4	256.6	253.6	250.7	248.0	245.7	243.3	241.8	240.8	240.3	240.1
0.894	0.500	258.5	257.5	256.0	253.5	250.8	248.2	245.7	243.9	242.1	240.8	239.7	239.0	238.9
1.018	0.	261.8	260.9	259.3	256.4	253.3	250.3	247.3	244.9	242.7	241.2	240.0	239.2	239.0
1.018	0.500	258.9	257.7	256.0	253.1	250.3	247.7	245.0	243.2	241.4	240.0	238.8	238.1	237.9
1.143	0.	262.3	261.2	259.5	256.3	253.1	250.1	246.9	244.4	242.3	240.8	239.5	238.7	238.4
1.143	0.500	259.3	257.8	255.8	252.7	249.7	247.1	244.3	242.4	240.7	239.3	238.1	237.3	237.1
1.267	0.	262.4	261.3	259.4	256.0	252.7	249.6	246.5	243.9	241.7	240.3	239.0	238.1	
1.267	0.500	259.9	258.3	256.1	252.9	249.9	247.1	244.4	242.3	240.6	239.3	238.1	237.2	
1.392	0.	263.1	261.9	259.8	256.3	253.0	249.8	246.8	244.3	241.9	240.9	239.6	238.5	238.0
1.392	0.500	260.4	258.7	256.5	253.1	250.0	247.2	244.5	242.5	240.4	239.5	238.3	237.4	237.0
1.516	0.	263.6	262.4	260.1	256.6	253.1	249.9	247.1	244.6	242.0	241.2	240.2	238.9	238.2
1.516	0.500	260.9	259.2	256.8	253.3	250.2	247.2	244.7	242.6	240.3	239.6	238.6	237.5	236.9
1.640	0.	264.1	262.9	260.5	257.1	253.7	250.4	248.1	245.5	242.7	242.0	241.5	239.8	238.9
1.640	0.500	261.4	259.8	257.3	253.9	250.7	247.7	245.6	243.4	240.8	240.4	239.4	238.3	237.3
1.765	0.	264.9	263.6	261.0	257.6	254.4	251.5	249.5	246.9	243.8	243.0	242.8	240.9	239.4
1.765	0.500	262.0	260.4	257.6	254.3	251.2	248.3	246.6	244.2	241.4	241.0	240.2	239.0	237.7
1.890	0.	265.5	264.2	261.6	258.1	255.0	252.5	251.2	248.0	244.7	243.9	243.5	242.1	240.0
1.890	0.500	262.9	261.3	258.4	255.0	252.0	249.4	248.1	245.3	242.3	242.0	241.3	240.2	238.4
2.014	0.	266.7	265.1	262.4	259.0	256.1	253.9	253.3	249.5	245.8	245.1	244.6	244.1	241.4
2.014	0.500	264.2	262.2	259.2	255.8	253.0	250.6	249.6	246.4	243.3	243.1	242.3	241.5	239.5
2.138	0.	268.1	266.3	263.3	259.7	256.8	255.6	254.7	250.7	246.8	246.1	245.7	245.5	242.8
2.138	0.500	265.9	263.7	260.5	256.7	253.7	252.2	250.9	247.5	244.3	244.1	243.5	242.6	240.8
2.263	0.	270.1	268.0	264.5	260.5	257.5	257.9	255.6	251.5	247.8	246.8	246.1	246.3	244.3
2.263	0.500	268.0	265.6	261.7	257.6	254.4	253.7	251.8	248.2	245.1	244.6	243.9	243.3	241.8
2.387	0.	272.4	270.2	266.3	261.7	258.5	259.9	256.6	252.6	248.7	247.5	246.9	246.9	245.7
2.387	0.500	270.6	268.0	263.5	258.8	255.2	255.2	252.5	249.1	245.7	245.0	244.1	243.7	242.6
2.512	0.	274.4	272.2	268.0	262.9	259.2	260.9	256.9	252.6	248.8	247.4	246.7	246.6	245.9
2.512	0.500	273.1	270.7	265.8	260.1	256.2	256.4	253.1	249.6	246.2	245.2	244.3	243.7	243.3
2.636	0.	276.5	274.4	270.2	264.5	260.8	262.1	257.6	253.2	249.2	247.5	246.9	246.9	246.5
2.636	0.500	275.3	273.1	268.4	261.7	257.5	257.4	253.6	249.9	246.5	245.0	244.1	243.8	243.8
2.761	0.	278.1	276.0	272.1	266.3	262.5	263.0	258.1	253.7	249.6	247.6	247.1	247.3	247.0
2.761	0.500	277.0	274.9	270.6	263.6	258.8	258.2	254.1	250.3	246.7	245.0	244.1	243.9	243.9
2.885	0.													
2.885	0.500													
3.010	0.	278.9	277.1	273.7	268.7	265.2	264.2	258.9	254.5	250.4	248.0	247.8	248.8	248.3
3.010	0.375	277.9	276.1	272.7	267.4	262.3	260.4	255.7	251.9	248.2	246.1	245.5	246.2	246.0
3.010	0.250	278.2	276.3	272.8	267.6	263.0	261.6	256.7	252.7	248.9	246.7	246.2	246.9	246.6
3.010	0.125	278.6	276.8	273.5	268.2	264.1	263.0	257.9	253.7	249.7	247.4	246.9	247.9	247.5

Table 3 (cont'd.)

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL, (NOSE SECTION)

MACH NUMBER = 3.23
ANGLE OF ATTACK = 6 DEGREES
SUPPLY PRESSURE = 980 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.	0.	265.3	265.1	264.3	263.5	263.1	263.2	262.6	262.6	262.9	263.2	263.1	263.3	262.2
0.	0.500	246.1	245.5	245.8	243.6	244.5	244.9	242.8	243.2	243.2	244.0	243.1	243.0	242.1
0.068	0.	266.1	265.7	264.7	263.5	262.6	262.4	261.7	261.6	262.0	262.3	262.2	262.4	261.2
0.136	0.	266.4	265.8	264.7	263.3	261.9	261.4	260.6	260.5	260.6	260.7	260.5	260.3	259.7
0.136	0.500	252.4	251.3	249.2	248.3	246.5	245.7	244.9	245.6	246.0	246.0	245.6	245.6	244.5
0.204	0.	265.7	265.1	263.7	262.5	260.4	259.8	258.9	258.8	258.8	258.8	258.4	258.6	257.5
0.305	0.	263.1	262.5	261.1	259.7	257.5	256.7	255.5	255.4	255.2	254.9	254.5	254.5	253.5
0.305	0.500													
0.305	0.375	255.1	254.5	252.9	251.5	249.3	248.8	247.8	247.8	247.8	247.5	247.1	247.2	246.2
0.305	0.250	258.1	257.6	256.1	254.7	252.5	252.0	250.9	250.8	250.8	250.5	250.1	250.1	249.1
0.305	0.125	260.8	260.2	258.5	257.4	255.3	254.6	253.5	253.3	253.1	252.8	252.4	252.4	251.4
0.356	0.	261.4	260.8	259.4	258.0	255.8	255.0	253.6	253.5	253.2	252.9	252.4	252.4	251.2
0.407	0.	259.4	258.9	257.5	256.3	254.0	253.2	251.8	251.5	251.2	250.8	250.3	250.3	249.2
0.407	0.500	252.2	251.5	249.9	248.6	246.2	245.7	244.7	244.6	244.6	244.3	243.9	243.9	242.9
0.455	0.	258.4	257.7	256.4	254.9	252.8	252.0	250.7	250.3	249.9	249.6	249.2	249.0	247.8
0.520	0.	256.1	255.4	254.2	252.7	250.6	249.9	248.5	248.0	247.6	247.2	246.7	246.6	245.4
0.520	0.500	251.8	251.1	249.7	248.2	245.9	245.4	244.3	244.0	243.8	243.5	243.1	243.0	241.9
0.520	0.375	253.0	252.3	251.0	249.6	247.4	246.8	245.6	245.3	245.0	244.7	244.2	244.1	243.0
0.520	0.250	254.2	253.5	252.2	250.9	248.7	248.1	246.8	246.4	246.2	245.8	245.3	245.2	244.1
0.520	0.125	255.1	254.4	253.2	251.8	249.6	249.0	247.6	247.2	247.0	246.7	246.0	246.1	244.9

Table 3 (cont'd.)

TEMPERATURE DISTRIBUTION ON SPHERE-CONE MODEL. (CONE SECTION)

MACH NUMBER = 3.23
ANGLE OF ATTACK = 6 DEGREES
SUPPLY PRESSURE = 980 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

S/R	D	ROLL ANGLE (DEGREES) 0	15	30	45	60	75	90	105	120	135	150	165	180
		TEMPERATURE, °K												
0.645	0.	254.4	253.9	252.5	251.1	249.0	248.2	246.9	246.2	245.7	245.2	244.7	244.5	243.3
0.645	0.500	251.5	250.2	249.5	248.1	245.8	245.1	244.1	243.5	243.2	242.8	242.3	242.3	241.2
0.769	0.	253.7	253.4	251.9	250.5	248.4	247.6	246.2	245.2	244.7	244.1	243.5	243.3	242.1
0.769	0.500	251.1	250.7	249.1	247.8	245.4	244.8	243.6	242.8	242.4	241.9	241.5	241.4	240.4
0.894	0.	253.6	253.1	251.3	249.8	247.7	246.8	245.2	244.2	243.6	242.9	242.3	240.1	241.5
0.894	0.500	251.4	250.8	248.8	247.2	245.0	244.2	242.7	242.0	241.4	240.7	240.3	238.3	239.9
1.018	0.	253.4	253.3	250.9	249.1	247.0	245.9	244.2	243.0	242.5	241.7	241.0	240.9	239.6
1.018	0.500	251.3	251.0	248.4	246.4	244.3	243.3	241.6	240.7	240.3	239.5	239.0	239.1	237.9
1.143	0.	253.3	252.8	250.6	248.6	246.5	245.3	243.5	242.3	241.5	240.8	240.0	239.9	238.6
1.143	0.500	251.3	250.4	247.9	245.1	243.6	242.4	240.7	239.7	239.2	238.6	237.9	238.0	236.8
1.267	0.	253.3	252.7	250.3	248.1	245.9	244.5	242.7	241.3	240.4	239.7	238.9	238.7	237.2
1.267	0.500	251.6	250.7	247.9	245.7	243.5	242.0	240.5	239.2	238.6	238.0	237.4	237.3	236.1
1.392	0.	254.0	253.3	250.6	248.2	245.9	244.3	242.5	241.0	240.0	239.3	238.7	238.3	236.9
1.392	0.500	252.1	251.1	248.0	245.8	243.4	241.8	240.2	238.9	238.0	237.4	237.0	236.7	235.4
1.516	0.	254.7	253.9	250.8	248.2	245.7	243.9	242.1	240.6	239.5	238.7	238.1	237.5	236.0
1.516	0.500	252.9	251.8	248.3	245.7	243.1	241.4	239.7	238.3	237.2	236.6	236.2	235.6	234.3
1.640	0.	255.7	254.8	251.3	248.4	245.6	243.7	241.9	240.3	239.0	238.1	237.6	236.8	235.1
1.640	0.500	254.0	252.7	248.9	245.9	243.0	241.0	239.5	238.1	236.9	236.1	235.7	234.8	233.4
1.765	0.	256.9	255.9	252.2	248.8	245.5	243.6	241.7	240.0	238.6	237.4	236.9	236.0	234.2
1.765	0.500	255.1	253.8	249.7	246.1	242.7	240.6	239.1	237.6	236.4	235.2	235.1	234.0	232.4
1.890	0.	257.8	256.8	252.8	249.0	245.2	243.0	241.1	239.4	238.0	236.4	235.8	234.8	233.0
1.890	0.500	256.5	255.3	250.7	246.6	242.8	240.5	238.8	237.4	236.1	234.9	234.4	233.4	231.9
2.014	0.	259.3	258.3	253.8	249.6	245.4	243.0	241.0	239.2	237.8	236.3	235.2	233.5	232.5
2.014	0.500	258.1	256.9	251.8	247.3	242.9	240.4	238.7	237.2	236.0	234.5	233.7	232.1	231.2
2.138	0.	260.7	259.6	254.9	250.2	245.6	242.9	240.8	239.0	237.7	236.1	233.7	233.0	231.9
2.138	0.500	259.7	258.4	253.3	248.1	243.3	240.6	238.6	237.1	235.9	234.4	232.3	231.7	230.8
2.263	0.	262.2	261.1	256.3	250.8	246.0	243.0	240.7	239.0	237.8	236.1	232.3	232.7	231.4
2.263	0.500	261.2	260.0	254.7	248.7	243.6	240.6	239.5	237.0	235.9	234.4	230.6	233.5	230.3
2.387	0.	263.6	262.6	257.8	251.8	246.5	243.5	241.0	239.4	238.3	236.8	230.6	233.0	231.6
2.387	0.500	262.6	261.4	256.3	249.6	244.0	240.9	238.6	237.1	236.1	234.7	228.7	231.5	230.2
2.512	0.	264.7	263.6	259.0	252.7	246.9	243.6	241.0	239.5	238.5	237.4	234.7	232.9	231.4
2.512	0.500	264.0	262.7	257.8	250.8	244.7	241.3	238.9	237.6	236.8	235.5	233.1	231.8	230.5
2.636	0.	265.8	264.7	260.2	253.9	247.5	244.0	241.4	240.0	239.2	238.6	235.9	233.6	231.8
2.636	0.500	265.1	264.0	259.1	252.1	245.3	241.7	239.2	237.9	237.3	236.4	234.0	232.2	230.8
2.761	0.	266.6	265.6	261.2	255.0	248.4	244.5	242.1	240.8	240.3	240.1	237.8	234.5	232.4
2.761	0.500	265.8	264.7	260.0	253.3	246.0	242.1	239.6	238.4	238.1	237.4	235.3	232.9	231.2
2.885	0.													
2.885	0.500													
3.010	0.	266.3	265.5	261.7	256.3	249.9	245.7	243.8	242.7	242.5	243.2	242.0	237.5	234.3
3.010	0.375	265.5	264.7	260.8	255.3	248.4	243.9	241.8	240.6	240.5	240.7	239.3	235.9	233.3
3.010	0.250	265.7	264.9	260.9	255.4	248.7	244.4	242.3	241.1	241.0	241.4	240.0	236.4	233.7
3.010	0.125	265.9	265.3	261.4	255.9	249.4	245.1	243.0	241.8	241.7	242.2	241.0	237.1	234.0

Table 4

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (NOSE SECTION)

MACH NUMBER = 4.8
ANGLE OF ATTACK = 18.0 DEGREES
SUPPLY PRESSURE = 2090.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

ROLL ANGLE	DIMENSIONLESS CONTOUR LENGTH								
	0.465	0.411	0.356	0.301	0.246	0.192	0.137	0.082	0.027
	(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)								
0.	0.2562	0.3270	0.3933	0.4811	0.5529	0.6032	0.6414	0.6408	0.5983
15.	0.2616	0.3190	0.3855	0.4512	0.5140	0.5710	0.5924	0.5938	0.5800
30.	0.2293	0.2909	0.3571	0.4388	0.5006	0.5331	0.5408	0.5405	0.5493
45.	0.1888	0.2429	0.3237	0.3987	0.4487	0.5014	0.5242	0.5355	0.5540
60.	0.2065	0.2115	0.2971	0.3664		0.4709	0.5058	0.5233	0.5665
75.	0.1558	0.1953	0.2637	0.3413	0.4306	0.4979	0.5239	0.5218	0.5344
90.	0.1156	0.1627	0.2163	0.2858	0.3392	0.3884	0.4590	0.5282	0.5547
105.	0.0835	0.1182	0.1680	0.2400	0.3214	0.3795	0.4515	0.5127	0.5499
120.	0.0694	0.1053	0.1617	0.2205	0.2940	0.3502	0.4102	0.4678	0.5421
135.	0.0641	0.0851	0.1371	0.1852	0.2538	0.3287	0.4028	0.4715	0.5282
150.	0.0639	0.0915	0.1256	0.1933	0.2654	0.3216	0.4022	0.4737	0.5303
165.	0.0498	0.0700	0.0987	0.1581	0.2156	0.2986	0.3891	0.4735	0.5470
180.	0.0651	0.0815	0.1105	0.1570	0.2286	0.2916	0.3741	0.4456	0.5281

Table 4 (cont'd.)

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (CONE SECTION)

MACH NUMBER = 4.8
ANGLE OF ATTACK = 15.0 DEGREES
SUPPLY PRESSURE = 2090.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 320.0 DEGREES KELVIN

DIMENSIONLESS CONTOUR LENGTH

(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)

ROLL ANGLE	0.520	0.645	0.769	0.894	1.018	1.143	1.267	1.392	1.516	1.640
0.	0.2207	0.1341	0.1378	0.1210	0.1185	0.1286	0.1039	0.1276	0.1213	0.1279
15.	0.1559	0.1544	0.1372	0.1258	0.1339	0.1325	0.1185	0.1334	0.1467	0.1397
30.	0.1699	0.1173	1.5136	0.1078	0.1132	0.1276	0.1061	0.1275	0.1347	0.1307
45.	0.1484	0.0993	0.1093	0.1044	0.1000	0.1138	0.0932	0.1048	0.1020	0.1071
60.	0.1365	0.0747	0.0895	0.0788	0.0822	0.0981	0.0710	0.0848	0.0795	0.0925
75.	0.0824	0.0748	0.0808	0.0776	0.0610	0.0784	0.0477	0.0808	0.0568	0.0788
90.	0.0957	0.0542	0.0551	0.0442	0.0495	0.0585	0.0506	0.0494	0.0484	0.0544
105.	0.1006	0.0469	0.0435	0.0276	0.0414	0.0417	0.0260	0.0467	0.0365	0.0448
120.	0.0531	0.0334	0.0401	0.0311	0.0346	0.0366	0.0197	0.0421	0.0508	0.0409
135.	0.0746	0.0291	0.0400	0.0324	0.0325	0.0333	0.0183	0.0406	0.0248	0.0307
150.	0.0440	0.0305	0.0423	0.0358	0.0288	0.0303	0.0158	0.0342	0.0278	0.0319
165.	0.0726	0.0311	0.0446	0.0377	0.0254	0.0257	0.0177	0.0310	0.0226	0.0343
180.	0.0723	0.0223	0.0408	0.0394	0.0242	0.0267	0.0109	0.0322	0.0242	0.0321

DIMENSIONLESS CONTOUR LENGTH

(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)

ROLL ANGLE	1.765	1.890	2.014	2.138	2.263	2.387	2.512	2.636	2.761	2.885
0.	0.1290	0.1129	0.1069	0.1112	0.1018	0.1261	0.0901	0.1044	0.1266	0.0268
15.	0.1480	0.1331	0.1368	0.1417	0.1144	0.1545	0.1362	0.1134	0.1642	0.0603
30.	0.1298	0.1240	0.1266	0.1155	0.1131	0.1305	0.1038	0.1242	0.1390	0.0728
45.	0.1176	0.0995	0.1257	0.0968	0.0967	0.0921	0.0903	0.1001	0.1059	0.0390
60.	0.1017	0.0764	0.0921	0.0842	0.0829	0.0915	0.0804	0.0770	0.0931	0.0459
75.	0.0801	0.0692	0.0740	0.0667	0.0642	0.0785	0.0608	0.0636	0.0828	0.0304
90.	0.0591	0.0480	0.0524	0.0543	0.0502	0.0666	0.0466	0.0573	0.0633	0.0273
105.	0.0468	0.0331	0.0380	0.0434	0.0316	0.0467	0.0346	0.0409	0.0523	0.0149
120.	0.0451	0.0223	0.0335	0.0339	0.0214	0.0373	0.0212	0.0274	0.0321	0.0084
135.	0.0366	0.0238	0.0243	0.0273	0.0187	0.0327	0.0198	0.0209	0.0338	0.0031
150.	0.0375	0.0253	0.0170	0.1182	0.0091	0.0294	0.0159	0.0135	0.0273	0.0023
165.	0.0360	0.0268	0.0338	0.0195	0.0182	0.0347	0.0200	0.0142	0.0316	0.0025
180.	0.0351	0.0160	0.0285	0.0222	0.0221	0.0352	0.0195	0.0158	0.0356	0.0025

Table 4 (cont'd.)

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (NOSE SECTION)

MACH NUMBER = 3.2
ANGLE OF ATTACK =18.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

ROLL ANGLE	DIMENSIONLESS CONTOUR LENGTH								
	0.465	0.411	0.356	0.301	0.246	0.192	0.137	0.082	0.027
	(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)								
0.	0.2125	0.2935	0.3723	0.4710	0.5296	0.5911	0.6400	0.6104	0.5765
15.	0.2182	0.2932	0.3759	0.4766	0.5345	0.5700	0.6278	0.6054	0.5827
30.	0.2296	0.3003	0.3835	0.4494	0.4948	0.5629	0.6079	0.6117	0.6011
45.	0.1922	0.2562	0.3255	0.4020	0.4686	0.5164	0.5931	0.6272	0.5827
60.	0.1661	0.2283	0.2948	0.3631	0.4288	0.4888	0.5508	0.5796	0.5978
75.	0.1337	0.2038	0.2691	0.3290	0.4102	0.4635	0.5293	0.5715	0.5959
90.	0.1220	0.1690	0.2316	0.2966	0.3603	0.4195	0.5007	0.5729	0.5981
105.	0.0889	0.1410	0.1967	0.2513	0.3126	0.3763	0.4549	0.5128	0.5780
120.	0.0576	0.1099	0.1667	0.2269	0.2890	0.3647	0.4333	0.5090	0.5554
135.	0.0460	0.0859	0.1344	0.2033	0.2702	0.3319	0.4100	0.4682	0.5267
150.	0.0346	0.0722	0.1150	0.1855	0.2481	0.3004	0.3938	0.4657	0.5346
165.	0.0382	0.0687	0.1092	0.1502	0.2398	0.3030	0.3751	0.4544	0.5309
180.	0.0364	0.0654	0.1044	0.1579	0.2045	0.2871	0.3650	0.4513	0.5374

Table 4 (cont'd.)

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (CONE SECTION)

MACH NUMBER = 3.2
ANGLE OF ATTACK = 18.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

DIMENSIONLESS CONTOUR LENGTH

(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)

ROLL ANGLE	0.520	0.645	0.769	0.894	1.018	1.143	1.267	1.392	1.516	1.640
0.	0.1094	0.0478	0.1084	0.1151	0.1103	0.1165	0.1140	0.1165	0.1218	0.1249
15.	0.1098	0.1881	0.1117	0.1379	0.1420	0.1393	0.1453	0.1434	0.1362	0.1408
30.	0.1078		0.0792	0.1176	0.1284	0.1278	0.1217	0.1241	0.1261	0.1212
45.	0.0721	0.1996	0.0839	0.1081	0.1136	0.1187	0.1166	0.1111	0.1115	0.1086
60.	0.0847	0.1078	0.0889	0.0872	0.0883	0.0893	0.0823	0.0919	0.0856	0.0962
75.	0.0374	0.0741	0.0725	0.0791	0.0792	0.0778	0.0767	0.0752	0.0775	0.0756
90.	0.0213	0.0870	0.0779	0.0641	0.0595	0.0667	0.0671	0.0674	0.0712	0.0775
105.	0.0070	0.0239	0.0366	0.0421	0.0440	0.0412	0.0304	0.0412	0.0427	0.0528
120.	0.0132	0.0396	0.0307	0.0201	0.0185	0.0159	0.0216	0.0238	0.0261	0.0319
135.		0.0171	0.0196	0.0138	0.0253	0.0315	0.0322	0.0348	0.0397	0.0454
150.	0.0127	0.0303	0.0241	0.0221	0.0187	0.0249	0.0206	0.0295	0.0401	0.0491
165.	0.0237	0.0297	0.0281	0.0205	0.0227	0.0229	0.0095	0.0084	0.0162	0.0343
180.	0.0250	0.0375	0.0334	0.0258	0.0165	0.0241	0.0402	0.0296	0.0251	0.0175

DIMENSIONLESS CONTOUR LENGTH

(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)

ROLL ANGLE	1.765	1.890	2.014	2.138	2.263	2.387	2.512	2.636	2.761	2.885
0.	0.1235	0.1122	0.1204	0.1063	0.1136	0.0902	0.0922	0.1056	0.1101	0.0990
15.	0.1309	0.1273	0.1220	0.1159	0.1265	0.1344	0.1165	0.1186	0.1035	0.0892
30.	0.1206	0.1198	0.1136	0.1019	0.0917	0.0943	0.0950	0.1109	0.1010	0.0950
45.	0.1063	0.1050	0.1101	0.1086	0.0991	0.0967	0.0939	0.0980	0.1120	0.1048
60.	0.0979	0.0972	0.0975	0.1065	0.0867	0.0912	0.1037	0.0944	0.1097	0.1328
75.	0.0834	0.0908	0.0995	0.1215	0.1762	0.1931	0.2155	0.2386	0.2454	0.2460
90.	0.0895	0.1206	0.1502	0.1598	0.1729	0.1737	0.1768	0.1678	0.1650	0.1623
105.	0.0707	0.0830	0.0923	0.1020	0.1090	0.1122	0.1099	0.1122	0.1158	0.1137
120.	0.0508	0.0477	0.0547	0.0592	0.0872	0.0734	0.0690	0.0741	0.0822	0.0894
135.	0.0484	0.0494	0.0616	0.1034	0.2323	0.1077	0.0680	0.0615	0.0617	0.0683
150.	0.0674	0.0742	0.0772	0.0788	0.0809	0.0720	0.0621	0.0707	0.0719	0.0816
165.	0.0401	0.0600	0.0823	0.1034	0.1025	0.1072	0.1083	0.1047	0.1026	0.1065
180.	0.0170	0.0163	0.0202	0.0296	0.0588	0.0592	0.0695	0.0763	0.0823	0.0939

Table 4 (cont'd.)

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (NOSE SECTION)

MACH NUMBER = 5.2
ANGLE OF ATTACK = 6.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

DIMENSIONLESS CONTOUR LENGTH

(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)

ROLL ANGLE	0.465	0.411	0.356	0.301	0.246	0.192	0.137	0.082	0.027
0.	0.1826	0.2290	0.3056	0.3995	0.4781	0.5534	0.6032	0.6103	0.6142
15.	0.1974	0.2241	0.2983	0.4051	0.4642	0.5324	0.5899	0.6046	0.6183
30.	0.1699	0.2174	0.2923	0.3814	0.4459	0.5136	0.5638	0.5854	0.6068
45.	0.1384	0.2090	0.2717	0.3416	0.4202	0.4726	0.5307	0.5448	0.5781
60.	0.1601	0.1969	0.2521	0.2996	0.3752	0.4385	0.4674	0.4904	0.5525
75.	0.1439	0.1734	0.2374	0.2903	0.3538	0.4129	0.4672	0.4897	0.5499
90.	0.1356	0.1746	0.2212	0.2724	0.3603	0.4230	0.4768	0.4940	0.5452
105.	0.1171	0.1590	0.2125	0.2886	0.3611	0.4276	0.4852	0.5250	0.5603
120.	0.1063	0.1568	0.2050	0.2852	0.3482	0.4336	0.4920	0.5454	
135.	0.1062	0.1473	0.1988	0.2827	0.3509	0.4443	0.5016	0.5592	0.5812
150.	0.1070	0.1482	0.2047	0.2811	0.3581	0.4318	0.4990	0.5684	0.5875
165.	0.0958	0.1477	0.1986	0.2836	0.3565	0.4278	0.5073	0.5733	0.5912
180.	0.0939	0.1442	0.2048	0.2878	0.3600	0.4312	0.5096	0.5749	0.5924

Table 4 (cont'd.)

HEAT TRANSFER COEFFICIENT ON SPHERE-CONE MODEL, (CONE SECTION)

MACH NUMBER = 3.2
ANGLE OF ATTACK = 6.0 DEGREES
SUPPLY PRESSURE = 980.0 MILLIMETERS OF HG.
SUPPLY TEMPERATURE = 318.0 DEGREES KELVIN

DIMENSIONLESS CONTOUR LENGTH

ROLL ANGLE	0.520	0.645	0.767	0.894	1.018	1.143	1.267	1.392	1.516	1.640
	(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)									
0.	0.1563	0.0982	0.0786	0.0817	0.0702	0.0745	0.0575	0.0713	0.0694	0.0744
15.	0.1551	0.0958	0.0913	0.0796	0.1050	0.0806	0.0709	0.0816	0.0818	0.0860
30.	0.1247	0.0847	0.0836	0.0731	0.0706	0.0791	0.0620	0.0725	0.0656	0.0680
45.	0.0508	0.1055	0.1020	0.0943	0.0875	0.0996	0.0719	0.0803	0.0758	0.0788
60.	0.1477	0.0650	0.0713	0.0660	0.0677	0.0780	0.0575	0.0700	0.0675	0.0730
75.	0.1249	0.0720	0.0807	0.0755	0.0712	0.0782	0.0585	0.0669	0.0628	0.0689
90.	0.1095	0.0752	0.0771	0.0719	0.0694	0.0736	0.0591	0.0690	0.0688	0.0722
105.	0.1087	0.0652	0.0665	0.0619	0.0564	0.0648	0.0455	0.0581	0.0578	0.0591
120.	0.0671	0.0618	0.0647	0.0613	0.0603	0.0612	0.0417	0.0528	0.0531	0.0518
135.	0.0664	0.0508	0.0530	0.0429	0.0481	0.0523	0.0356	0.0459	0.0470	0.0468
150.	0.0922	0.0537	0.0535	0.0519	0.0493	0.0490	0.0307	0.0501	0.0500	0.0552
165.	0.0394	0.0453	0.0444	0.0448	0.0432	0.0458	0.0267	0.0425	0.0409	0.0460
180.	0.0197	0.0444	0.0451	0.0375	0.0394	0.0442	0.0172	0.0385	0.0363	0.0349

DIMENSIONLESS CONTOUR LENGTH

ROLL ANGLE	1.765	1.890	2.014	2.138	2.263	2.387	2.512	2.636	2.761	2.885
	(NUSSELT NO.)/(SQUARE ROOT OF REYNOLDS NO.)									
0.	0.0778	0.0544	0.0584	0.0554	0.0549	0.0602	0.0475	0.0497	0.0581	0.0577
15.	0.0891	0.0681	0.0738	0.0669	0.0660	0.0759	0.0570	0.0594	0.0657	0.0648
30.	0.0761	0.0600	0.0602	0.0535	0.0577	0.0657	0.0566	0.0605	0.0639	0.0587
45.	0.0833	0.0688	0.0721	0.0655	0.0625	0.0680	0.0605	0.0625	0.0675	0.0569
60.	0.0737	0.0551	0.0618	0.0564	0.0602	0.0648	0.0505	0.0529	0.0598	0.0733
75.	0.0772	0.0564	0.0617	0.0543	0.0553	0.0692	0.0563	0.0576	0.0598	0.0600
90.	0.0780	0.0613	0.0675	0.0595	0.0595	0.0673	0.0523	0.0550	0.0674	0.0664
105.	0.0670	0.0497	0.0543	0.0492	0.0494	0.0608	0.0476	0.0499	0.0588	0.0689
120.	0.0573	0.0445	0.0494	0.0464	0.0479	0.0586	0.0436	0.0496	0.0551	0.0752
135.	0.0490	0.0259	0.0393	0.0370	0.0392	0.0540	0.0479	0.0611	0.0745	0.0917
150.	0.0591	0.0382	0.0435	0.0344	0.0293	0.0397	0.0292	0.0433	0.0665	0.0957
165.	0.0489	0.0324	0.0159	0.0201	0.0191	0.0327	0.0144	0.0237	0.0276	0.0366
180.	0.0368	0.0164	0.0305	0.0262	0.0198	0.0318	0.0144	0.0245	0.0355	0.1096

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A1)

	No. of Copies
Chief, Bureau of Naval Weapons Department of the Navy Washington 25, D. C.	
Attn: DLI-30	1
Attn: R-14	1
Attn: RRRE-4	1
Attn: RMGA-413	1
Office of Naval Research Room 2709, T-3 Washington 25, D. C. Attn: Head, Mechanics Branch	1
Director, David Taylor Model Basin Aerodynamics Laboratory Washington 7, D. C. Attn: Library	1
Commander, U. S. Naval Ordnance Test Station China Lake, California	
Attn: Technical Library	1
Attn: Code 503	1
Attn: Code 406	1
Director, Naval Research Laboratory Washington 25, D. C. Attn: Code 2027	1
Commanding Officer Office of Naval Research Branch Office Box 39, Navy 100 Fleet Post Office New York, New York	1
NASA High Speed Flight Station Box 273 Edwards Air Force Base, California Attn: W. C. Williams	1
NASA Ames Research Center Moffett Field, California Attn: Librarian	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A1)

	No. of Copies
NASA Langley Research Center Langley Field, Virginia	
Attn: Librarian	3
Attn: C. H. McLellan	1
Attn: J. J. Stack	1
Attn: Adolf Busemann	1
Attn: Comp. Res. Div.	1
Attn: Theoretical Aerodynamics Division	1
NASA Lewis Research Center 21000 Brookpark Road Cleveland 11, Ohio	
Attn: Librarian	1
Attn: Chief, Propulsion Aerodynamics Div.	1
NASA 1520 H Street, N. W. Washington 25, D. C.	
Attn: Chief, Division of Research Information	1
Attn: Dr. H. H. Kurzweg, Asst. Director of Research	1
Office of the Assistant Secretary of Defense (R&D) Room 3E1065, The Pentagon Washington 25, D. C.	
Attn: Technical Library	1
Research and Development Board Room 3D1041, The Pentagon Washington 25, D. C.	
Attn: Library	1
ASTIA Arlington Hall Station Arlington 12, Virginia	10
Commander, Pacific Missile Range Point Mugu, California	
Attn: Technical Library	1
Commanding General Aberdeen Proving Ground, Maryland	
Attn: Technical Information Branch	1
Attn: Ballistic Research Laboratory	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A1)

	No. of Copies
Commander, Naval Weapons Laboratory Dahlgren, Virginia Attn: Library	1
Director, Special Projects Department of the Navy Washington 25, D. C. Attn: SP-2722	1
Director of Intelligence Headquarters, USAF Washington 25, D. C. Attn: AFOIN-3B	1
Headquarters - Aero. Systems Division Wright-Patterson Air Force Base Dayton, Ohio Attn: WWAD Attn: RRLA-Library	 2 1
Commander Air Force Ballistic Missile Division HQ Air Research & Development Command P. O. Box 262 Inglewood, California Attn: WDTLAR	1
Chief, Defense Atomic Support Agency Washington 25, D. C. Attn: Document Library	1
Headquarters, Arnold Engineering Development Center Air Research and Development Center Arnold Air Force Station, Tennessee Attn: Technical Library Attn: AEOR Attn: AEOIM	 1 1 1
Commanding Officer, DOFL Washington 25, D. C. Attn: Library, Room 211, Bldg. 92	1
Commanding General Redstone Arsenal Huntsville, Alabama Attn: Mr. N. Shapiro (ORDDW-MRF) Attn: Technical Library	 1 1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A1)

	No. of Copies
NASA George C. Marshall Space Flight Center Huntsville, Alabama	
Attn: Dr. E. Geissler	1
Attn: Mr. T. Reed	1
Attn: Mr. H. Paul	1
Attn: Mr. W. Dahm	1
Attn: Mr. D. Burrows	1
Attn: Mr. J. Kingsbury	1
Attn: ORDAB-DA	1
APL/JHU (C/NOw 7386) 8621 Georgia Avenue Silver Spring, Maryland	
Attn: Technical Reports Group	2
Attn: Mr. D. Fox	1
Attn: Dr. F. Hill	1
Via: INSORD	
Air Force Systems Command Scientific & Technical Liaison Office Room 2305, Munitions Building Department of the Navy Washington 25, D. C.	
Attn: E. G. Haas	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
University of Minnesota Minneapolis 14, Minnesota	
Attn: Dr. E. R. G. Eckert	1
Attn: Heat Transfer Laboratory	1
Attn: Technical Library	1
Rensselaer Polytechnic Institute Troy, New York	
Attn: Dept. of Aeronautical Engineering	1
Dr. James P. Hartnett Department of Mechanical Engineering University of Delaware Newark, Delaware	1
Princeton University James Forrestal Research Center Gas Dynamics Laboratory Princeton, New Jersey	
Attn: Prof. S. Bogdonoff	1
Attn: Dept. of Aeronautical Engineering Library	1
Defense Research Laboratory The University of Texas P. O. Box 8029 Austin 12, Texas	
Attn: Assistant Director	1
Ohio State University Columbus 10, Ohio	
Attn: Security Officer	1
Attn: Aerodynamics Laboratory	1
Attn: Dr. J. Lee	1
Attn: Chairman, Dept. of Aero. Engineering	1
California Institute of Technology Pasadena, California	
Attn: Guggenheim Aero. Laboratory, Aeronautics Library	1
Attn: Jet Propulsion Laboratory	1
Attn: Dr. H. Liepmann	1
Attn: Dr. L. Lees	1
Attn: Dr. D. Coles	1
Attn: Mr. A. Roshko	1
Attn: Dr. J. Laufer	1
Case Institute of Technology Cleveland 6, Ohio	
Attn: G. Kuerti	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
North American Aviation, Inc.	
Aerophysics Laboratory	
Downing, California	
Attn: Dr. E. R. Van Driest	1
Attn: Missile Division (Library)	1
Department of Mechanical Engineering	
Yale University	
400 Temple Street	
New Haven 10, Connecticut	
Attn: Dr. P. P. Wegener	1
Attn: Prof. N. A. Hall	1
MIT Lincoln Laboratory	1
Lexington, Massachusetts	
RAND Corporation	
1700 Main Street	
Santa Monica, California	
Attn: Library, USAF Project RAND	1
Attn: Technical Communications	1
Mr. J. Lukasiewicz	1
Chief, Gas Dynamics Facility	
ARO, Incorporated	
Tullahoma, Tennessee	
Massachusetts Institute of Technology	
Cambridge 39, Massachusetts	
Attn: Prof. J. Kaye	1
Attn: Prof. M. Finston	1
Attn: Mr. J. Baron	1
Attn: Prof. A. H. Shapiro	1
Attn: Naval Supersonic Laboratory	1
Attn: Aero. Engineering Library	1
Polytechnic Institute of Brooklyn	
527 Atlantic Avenue	
Freeport, New York	
Attn: Dr. A. Ferri	1
Attn: Dr. M. Bloom	1
Attn: Dr. P. Libby	1
Attn: Aerodynamics Laboratory	1
Brown University	
Division of Engineering	
Providence, Rhode Island	
Attn: Prof. R. Probstein	1
Attn: Prof. C. Lin	1
Attn: Librarian	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Air Ballistics Laboratory	1
Army Ballistic Missile Agency	
Huntsville, Alabama	
Applied Mechanics Reviews	1
Southwest Research Institute	
8500 Culebra Road	
San Antonio 6, Texas	
BuWeps Representative	1
Aerojet-General Corporation	
6352 N. Irwindale Avenue	
Azusa, California	
Boeing Airplane Company	
Seattle, Washington	
Attn: J. H. Russell	1
Attn: Research Library	1
United Aircraft Corporation	
400 Main Street	
East Hartford 8, Connecticut	
Attn: Chief Librarian	1
Attn: Mr. W. Kuhrt, Research Dept.	2
Attn: Mr. J. G. Lee	1
Hughes Aircraft Company	
Florence Avenue at Teale Streets	
Culver City, California	
Attn: Mr. D. J. Johnson	1
R&D Technical Library	
McDonnell Aircraft Corporation	1
P. O. Box 516	
St. Louis 3, Missouri	
Lockheed Missiles and Space Company	
P. O. Box 504	
Sunnyvale, California	
Attn: Dr. L. H. Wilson	1
Attn: Mr. M. Tucker	1
Attn: Mr. R. Smelt	1
The Martin Company	
Baltimore 3, Maryland	
Attn: Library	1
Attn: Chief Aerodynamicist	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
CONVAIR A Division of General Dynamics Corporation Fort Worth, Texas	
Attn: Library	1
Attn: Theoretical Aerodynamics Group	1
Purdue University School of Aeronautical & Engineering Sciences LaFayette, Indiana	
Attn: R. L. Taggart, Library	1
University of Maryland College Park, Maryland	
Attn: Director	2
Attn: Dr. J. Burgers	1
Attn: Librarian, Engr. & Physical Sciences	1
Attn: Librarian, Institute for Fluid Dynamics and Applied Mathematics	1
University of Michigan Ann Arbor, Michigan	
Attn: Dr. A. Kuethe	1
Attn: Dr. O. Laporte	1
Attn: Department of Aeronautical Engineering	1
Stanford University Palo Alto, California	
Attn: Applied Mathematics & Statistics Lab.	1
Attn: Prof. D. Bershader, Dept. of Aero. Engr.	1
Cornell University Graduate School of Aeronautical Engineering Ithaca, New York	
Attn: Prof. W. R. Sears	1
The Johns Hopkins University Charles and 34th Streets Baltimore, Maryland	
Attn: Dr. F. H. Clauser	1
Attn: Dr. M. Morkovin	1
University of California Berkeley 4, California	
Attn: G. Maslach	1
Attn: Dr. S. Schaaf	1
Attn: Dr. Holt	1
Attn: Institute of Engineering Research	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Cornell Aeronautical Laboratory, Inc. 4455 Genesee Street Buffalo 21, New York	
Attn: Librarian	1
Attn: Dr. Franklin Moore	1
Attn: Dr. J. G. Hall	1
University of Minnesota Rosemount Research Laboratories Rosemount, Minnesota	
Attn: Technical Library	1
Director, Air University Library Maxwell Air Force Base, Alabama	1
Douglas Aircraft Company, Inc. Santa Monica Division 3000 Ocean Park Boulevard Santa Monica California	
Attn: Chief Missiles Engineer	1
Attn: Aerodynamics Section	1
General Motors Corporation Defense Systems Division Santa Barbara, California	
Attn: Dr. A. C. Charters	1
CONVAIR A Division of General Dynamics Corporation Daingerfield, Texas	1
CONVAIR Scientific Research Laboratory 5001 Kearney Villa Road San Diego 11, California	
Attn: Mr. M. Sibulkin	1
Attn: Asst. to the Director of Scientific Research	1
Attn: Dr. B. M. Leadon	1
Attn: Library	1
Republic Aviation Corporation Farmingdale, New York	
Attn: Technical Library	1
General Applied Science Laboratories, Inc. Merrick and Stewart Avenues Westbury, L. I., New York	
Attn: Mr. Walter Daskin	1
Attn: Mr. R. W. Byrne	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Arnold Research Organization, Inc. Tullahoma, Tennessee	
Attn: Technical Library	1
Attn: Chief, Propulsion Wind Tunnel	1
Attn: Dr. J. L. Potter	1
General Electric Company Missile and Space Vehicle Department 3198 Chestnut Street Philadelphia, Pennsylvania	
Attn: Larry Chason, Mgr. Library	2
Attn: Mr. R. Kirby	1
Attn: Dr. J. Farber	1
Attn: Dr. G. Sutton	1
Attn: Dr. J. D. Stewart	1
Attn: Dr. S. M. Scala	1
Attn: Dr. H. Lew	1
Eastman Kodak Company Navy Ordnance Division 50 West Main Street Rochester 14, New York	
Attn: W. B. Forman	2
Library AVCO-Everett Research Laboratory 2385 Revere Beach Parkway Everett 49, Massachusetts	3
AVCO-Everett Research Laboratory 201 Lowell Street Wilmington, Massachusetts	
Attn: Mr. F. R. Riddell	1
AER, Incorporated 158 North Hill Avenue Pasadena, California	1
Armour Research Foundation 10 West 35th Street Chicago 16, Illinois	
Attn: Dept. M	2
Attn: Dr. Paul T. Torda	1
Chance-Vought Aircraft, Inc. Dallas, Texas	
Attn: Librarian	2

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
National Science Foundation 1951 Constitution Avenue, N. W. Washington 25, D. C. Attn: Engineering Sciences Division	1
New York University University Heights New York 53, New York Attn: Department of Aeronautical Engineering	1
New York University 25 Waverly Place New York 3, New York Attn: Library, Institute of Math. Sciences	1
NORAIR A Division of Northrop Corp. Hawthorne, California Attn: Library	1
Northrop Aircraft, Inc. Hawthorne, California Attn: Library	1
Gas Dynamics Laboratory Technological Institute Northwestern University Evanston, Illinois Attn: Library	1
Pennsylvania State University University Park, Pennsylvania Attn: Library, Dept. of Aero. Engineering	1
The Ramo-Wooldridge Corporation 8820 Bellanca Avenue Los Angeles 45, California	1
Gifts and Exchanges Fondren Library Rice Institute P. O. Box 1892 Houston 1, Texas	1
University of Southern California Engineering Center Los Angeles 7, California Attn: Librarian	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Commander Air Force Flight Test Center Edwards Air Force Base Muroc, California Attn: FTOTL	1
Air Force Office of Scientific Research Holloman Air Force Base Alamogordo, New Mexico Attn: SRLTL	1
The Editor Battelle Technical Review Battelle Memorial Institute 505 King Avenue Columbus 1, Ohio	1
Douglas Aircraft Company, Inc. El Segundo Division El Segundo, California	1
Fluidyne Engineering Corp. 5740 Wayzata Blvd. Golden Valley Minneapolis 16, Minnesota	1
Grumman Aircraft Engineering Corp. Bethpage, L. I., New York	1
Lockheed Missile and Space Company P. O. Box 551 Burbank, California Attn: Library	1
Marquardt Aircraft Corporation 7801 Havenhurst Van Nuys, California	1
The Martin Company Denver, Colorado Attn: Library	1
Mississippi State College Engineering and Industrial Research Station Aerophysics Department P. O. Box 248 State College, Mississippi	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Lockheed Missile and Space Company 3251 Hanover Street Palo Alto, California Attn: Mr. J. A. Laurmann Attn: Library	 1
General Electric Company Research Laboratory Schenectady, New York Attn: Dr. H. T. Nagamatsu Attn: Library	 1
Fluid Dynamics Laboratory Mechanical Engineering Department Stevens Institute of Technology Hoboken, New Jersey Attn: Dr. R. H. Page, Director	 1
Department of Mechanical Engineering University of Arizona Tucson, Arizona Attn: Dr. E. K. Parks	 1
Vitro Laboratories 200 Pleasant Valley Way West Orange, New Jersey Attn: Dr. Charles Sheer	 1
Department of Aeronautical Engineering University of Washington Seattle 5, Washington Attn: Prof. R. E. Street Attn: Library	 1 1
Aeronautical Engineering Review 2 East 64th Street New York 21, New York	1
Institute of the Aerospace Sciences 2 East 64th Street New York 21, New York Attn: Managing Editor Attn: Library	 1 1
Department of Aeronautics United States Air Force Academy Colorado	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
MHD Research, Inc. Newport Beach, California Attn: Dr. V. H. Blackman, Technical Director	1
University of Alabama College of Engineering University, Alabama Attn: Prof. C. H. Bryan, Head Dept. of Aeronautical Engineering	1
Office of Naval Research Bldg. T-3, Department of the Navy 17th and Constitution Avenue Washington 25, D. C. Attn: Mr. Ralph D. Cooper, Head Fluid Dynamics Branch	1
ARDE Associates 100 W. Century Road Paramus, New Jersey Attn: Mr. Edward Cooperman	1
Aeronautical Research Associates of Princeton 50 Washington Road Princeton, New Jersey Attn: Dr. C. duP. Donaldson, President	1
Daniel Guggenheim School of Aeronautics Georgia Institute of Technology Atlanta, Georgia Attn: Prof. A. L. Ducoffe	1
University of Cincinnati Cincinnati, Ohio Attn: Prof. R. P. Harrington, Head Dept. of Aeronautical Engineering	1
Virginia Polytechnic Institute Dept. of Aerospace Engineering Blacksburg, Virginia Attn: Mr. R. T. Keefe Attn: Library	1 1
IBM Federal System Division 7220 Wisconsin Avenue Bethesda, Maryland Attn: Dr. I. Korobkin	1

AERODYNAMICS DEPARTMENT
EXTERNAL DISTRIBUTION LIST (A2)

	No. of Copies
Superintendent U. S. Naval Postgraduate School Monterey, California Attn: Technical Reports Section Library	1
National Bureau of Standards Washington 25, D. C. Attn: Chief, Fluid Mechanics Section	1
North Carolina State College Raleigh, North Carolina Attn: Prof. R. W. Truitt, Head Dept. of Mechanical Engineering	1
Attn: Division of Engineering Research Technical Library	1

CATALOGING INFORMATION FOR LIBRARY USE

BIBLIOGRAPHIC INFORMATION

Descriptors	Codes	Descriptors	Codes
Source NOL technical report	NOLTR	Security Classification and Code Count Unclassified - 23	UØ23
Report Number 62-35	62ØØ35	Circulation Limitation	
Report Date 8 June 1962	Ø662	Circulation Limitation or Bibliographic	
		Bibliographic (Suppl., Vol., etc.)	

SUBJECT ANALYSIS OF REPORT

Descriptors	Codes	Descriptors	Codes	Descriptors	Codes
Bodies	BODY	Laminar	LAMI		
Heat transfer	HEAF	Turbulent	TUBU		
Pressure	PRES	Theory	THEY		
Yaw	YAWE	Measurements	MEAU		
Supersonic	SUPR	Testing equipment	TESR		
Aerodynamic	AERD	Wind tunnel	WINU		
Spheres	SPHE	Tests	TEST		
Cones	CONE	Instruments	INSM		
Mach	MACH	Temperature	TEMP		
Number	NUMB	Data reduction	DATR		
3.23	3XØØ	Bodies (Tests)	BODYT		
4.83	4X75				

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-35)
SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW, by Lionel Pasiuk. 8 June 1962. 10p. charts, tables, diagrs. (Aerodynamics research report 174) Task RMGA-42-034/212-1/F009-10-001. UNCLASSIFIED

Measurements of the static pressure and aerodynamic heat transfer on the surface of a sphere-cone model at Mach numbers of 3.23 and 4.83, and angles of yaw of 6° and 18° have been made. The results of several theoretical methods for calculating both the laminar and turbulent heat transfer to the body along the most windward and leeward streamlines are compared with the experimental measurements.

1. Bodies - Heat transfer
2. Bodies - Pressure
3. Bodies - Wind tunnel tests
4. Heat - Transference
I. Title
II. Pasiuk, Lionel
III. Series
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-35)
SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW, by Lionel Pasiuk. 8 June 1962. 10p. charts, tables, diagrs. (Aerodynamics research report 174) Task RMGA-42-034/212-1/F009-10-001. UNCLASSIFIED

Measurements of the static pressure and aerodynamic heat transfer on the surface of a sphere-cone model at Mach numbers of 3.23 and 4.83, and angles of yaw of 6° and 18° have been made. The results of several theoretical methods for calculating both the laminar and turbulent heat transfer to the body along the most windward and leeward streamlines are compared with the experimental measurements.

1. Bodies - Heat transfer
2. Bodies - Pressure
3. Bodies - Wind tunnel tests
4. Heat - Transference
I. Title
II. Pasiuk, Lionel
III. Series
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-35)
SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW, by Lionel Pasiuk. 8 June 1962. 10p. charts, tables, diagrs. (Aerodynamics research report 174) Task RMGA-42-034/212-1/F009-10-001. UNCLASSIFIED

Measurements of the static pressure and aerodynamic heat transfer on the surface of a sphere-cone model at Mach numbers of 3.23 and 4.83, and angles of yaw of 6° and 18° have been made. The results of several theoretical methods for calculating both the laminar and turbulent heat transfer to the body along the most windward and leeward streamlines are compared with the experimental measurements.

1. Bodies - Heat transfer
2. Bodies - Pressure
3. Bodies - Wind tunnel tests
4. Heat - Transference
I. Title
II. Pasiuk, Lionel
III. Series
IV. Project

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-35)
SUPERSONIC AERODYNAMIC HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON A SPHERE-CONE MODEL AT HIGH ANGLES OF YAW, by Lionel Pasiuk. 8 June 1962. 10p. charts, tables, diagrs. (Aerodynamics research report 174) Task RMGA-42-034/212-1/F009-10-001. UNCLASSIFIED

Measurements of the static pressure and aerodynamic heat transfer on the surface of a sphere-cone model at Mach numbers of 3.23 and 4.83, and angles of yaw of 6° and 18° have been made. The results of several theoretical methods for calculating both the laminar and turbulent heat transfer to the body along the most windward and leeward streamlines are compared with the experimental measurements.

1. Bodies - Heat transfer
2. Bodies - Pressure
3. Bodies - Wind tunnel tests
4. Heat - Transference
I. Title
II. Pasiuk, Lionel
III. Series
IV. Project